SURGICAL TECHNIQUE

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By

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Therefore since custom is the principal majistrate of man's life let men by all means endeavour to obtain good customs

Of Customs and Education Francis Bacon

PREFACE TO THE FIRST EDITION

IT is inevitable that a young surgeon s training must be largely academic with the result that though a Fellow of the Royal College of Surgeons he very often finds him self knowing a great deal more about operations than about operating I realised this as soon as I became a resident surgical officer but when I looked round for help in my difficulties I completely failed to find it The standard text books that I had studied took the minor technicalities for granted the vade mecums stopped short of them So far as I know the gap still exists and it was in the hope of bridging it that I set about writing the present volume having in mind the idea that I was to concern myself with the bricks and mortar of the surgeon s business and not the architecture

I am much indebted to Mr David Le Vay for writing the chapter on Orthopædic Surgery and to Mr C F Critchley for that on the Surgery of Children My father Dr J D Power made the original sketches and Mr E J Chandler and Dr T S MacDonald converted them to the more formal style required for reproduction Dr W H Myers spared no time or trouble in capturing the operative details that I wished to illustrate Dr S Goldman read through and corrected the proofs of the chapters on Shock Local Anæsthesia and Anæsthetic Emergencies To all of these I tender my sincerest thanks

Of the case notes some are my own others I have borrowed to anyone who recognises his property I make due acknowledgment Miss Elizabeth Jenkins marshalled and typed the manuscript and I am greatly in her debt for her painstaking labours Finally I would say how

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much I have appreciated the patient helpfulness of my publishers, and in particular Mr J Johnston Abraham and Mr Owen R Evans

STEPHEN POWER

LONDON, *August*, 1951

PREFACE TO THE SECOND EDITION

REVISION of this book has necessitated considerable alteration and addition For obvious reasons the accident risk in theatre work has received fresh attention and the need for bringing asepsis into line with modern requirements has been correspondingly stressed A section on catheter drainage the commonest and most abused of all forms of drainage has been added to the chapter on Drains For permission to reproduce this I am indebted to the Editor of the *Post Graduate Medical Journal* The chapter on Wound Surgery has been amended—the subject may become topical The chapter on Shock has been renamed Transfusion and Infusion and its contents altered accordingly There is an additional chapter on Instruments in Suturing which I had the invaluable assistance of Mr H Woodhall of Messrs Allen & Hanburys

CHAPTER I

GENERAL CONSIDERATIONS

How Long Should It Take ? Bareron Larey Napoleon s surgeon general amputated at the hip with two strokes of the knife in as many minutes But his operation fell into disrepute because his less skilled though equally enthu siastic colleagues sometimes sliced off the testicles as well as the limb With these men whether they were ampu tating or cutting for stone speed was a prime consideration because they worked without anæsthesia. Even when anæsthetics were introduced the ability to do the job in the minimum time was still highly prized chloroform and ether both having toxic effects when given in large doses and shock being an invariable accompaniment of long operations

Circumstances have changed and there is not now the pressing need for hurry The main essential is to do the work well not to get it finished as soon as possible Very often in surgery it is a case of the more hurry the less speed Fig 1 shows the chart of a case in which a hæmatoma formed in the wound picking up an additional bleeding point might have delayed the patient s return to the ward by a minute or two but it would have saved him an extra week in hospital

The tyro particularly should resist the temptation to try to do things as quickly as his seniors He will do much better if he slows down and his seniors will often rid themselves of an unnecessary tremor by sacrificing a little speed One sometimes wonders whether the urge to conclude an operation as quickly as possible is not a symptom of an anxiety state In any case no surgeon

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FIG 1 This herniorraphy case developed a hæmatoma, and showed signs of infection on the tenth day A few more minutes spent on hæmostasis in the theatre might have saved the patient an extra week in hospital

can work quicker than his team If he attempts to do so trouble is certain to result

It is not easy to describe how skill may be acquired except by simile and illustration Certainly timing seems to play a very important part The man who wants to improve his handwriting is advised to forget the words and concentrate on the letters So the surgeon should forget the anastomosis and concentrate on the individual stitch A homely anecdote from the back blocks teaches the same lesson A lumberjack watching the holiday visitors trying

to do his job remarked that they were so keen to cut the logs that they forgot to saw them

Here is a relevant quotation [1] There is one characteristic which crops up over and over again in descriptions of expert skilled performance The operator is said to have all the time in the world to do what he wants This has nothing to do with the absolute speed of the movements bodily or mental These may be almost incredibly quick or they may be leisurely and slow What is impressive is the absence of any appearance of hurry in the whole operation There is no jerkiness or snatching no obvious hurry to catch up in one part and forced sauntering to make up in another The time that is spoken of is really timing and if we could understand the simple timing mechanisms which the human body and mind must obviously be able to use and how they work we should have got some way at least towards a measure of degree or level of skill

The longer we practise any activity the more inessentials we learn to eliminate This is one of the best ways of saving time and perhaps one of the surest methods of achieving skill Lord Moynihan used to say that he never made an unnecessary movement when he was operating

System All this does not mean that time should be wasted. On the contrary by proceeding in a deliberate and orderly fashion it is always saved When operating (or describing an operation in an examination paper) one stage should invariably be completed before beginning the next This may sound like a platitude but it is one which is often ignored. A surgeon who has made himself master of a particular operation is an object lesson in this matter He forges steadily ahead and never wastes a minute by going on to something else before he has finished what he

[1] The Measurement of Human Skill *British Medical Journal* June 14th and 21st 1947

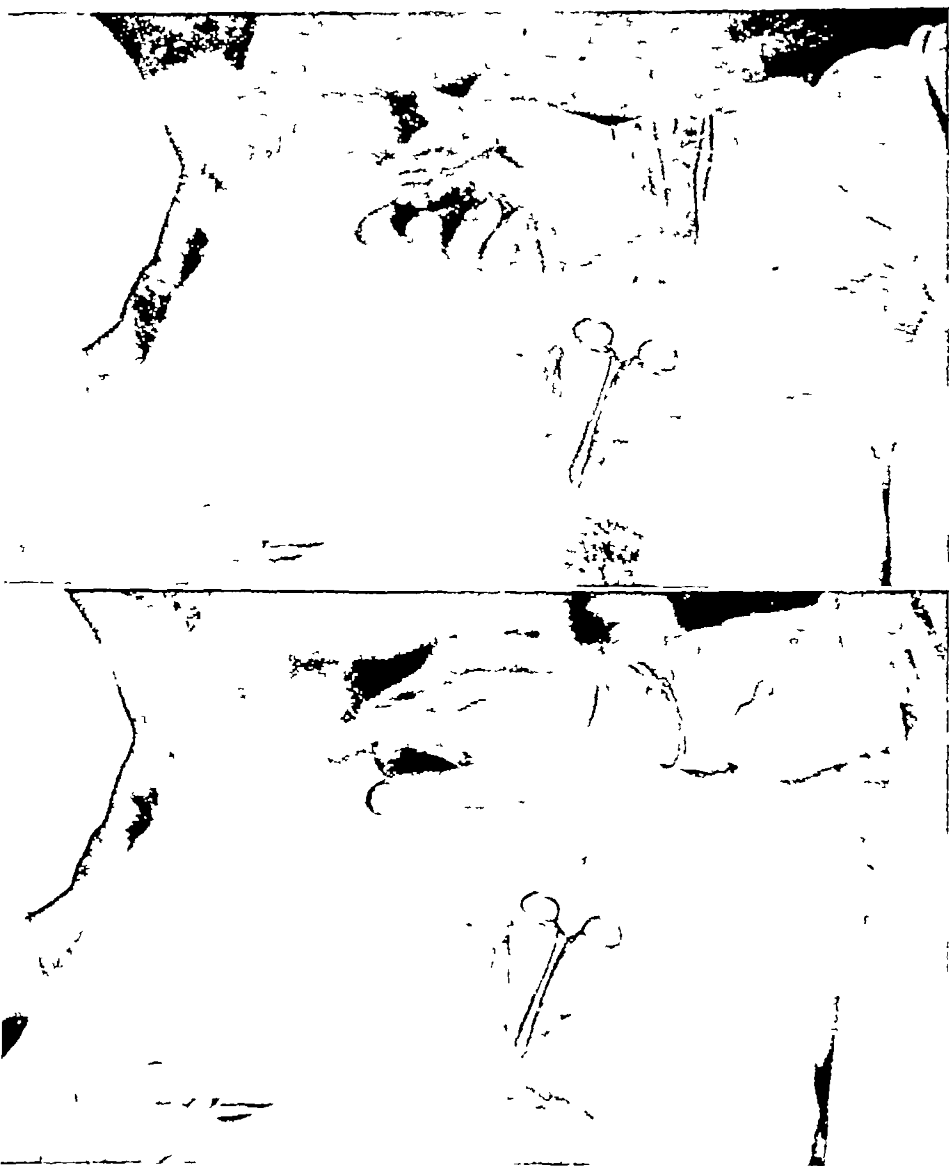


FIG. 2.—Time is saved by agreeing on a system of signals. For example: (1) "Sister, I want a pair of Spencer Wells"; (2) "Sister, I want a pair of scissors."

is about Order is in fact the secret by which he excels Watch the same man on unfamiliar ground and he may vacillate as much as anyone And yet it is when exploring unfamiliar ground that time is most precious

In most cases the stages can be divided up as follows

1 Exposure
2 Exploration
3 Mobilisation
4 The actual procedure
5 Toilet including swab count
6 Closure with or without drainage

There is a part of almost every operation where judgment initiative and even enterprise are required but this does not usually apply to the opening and closing stages which should be made as much a matter of routine as possible

It is good policy at least for the beginner to make a big exposure The next step exploration should be carried out as methodically as any of the others Haphazard search is bound to lead to oversight perhaps grave oversight such as the finding of a secondary in the liver halfway through a radical operation for cancer

Mobilisation should be adequate The mistake of trying to remove an organ or tumour before it is properly freed from its attachments and adhesions is only too common and inevitably causes delay The process of mobilising often involves the division of vessels and when it does it serves another very useful purpose—the control of hæmorrhage which is an essential preliminary to an excision

During the procedure itself a great deal of time can be saved if the surgeon has already in his mind exactly what he is going to do in any given combination of circumstances If the gut is viable I shall put it back If it is gangrenous I shall resect it if it is jejunum or do an ileostomy if it is ileum If an obstructed coil of gut is glued down in the depths of the pelvis I shall do a short

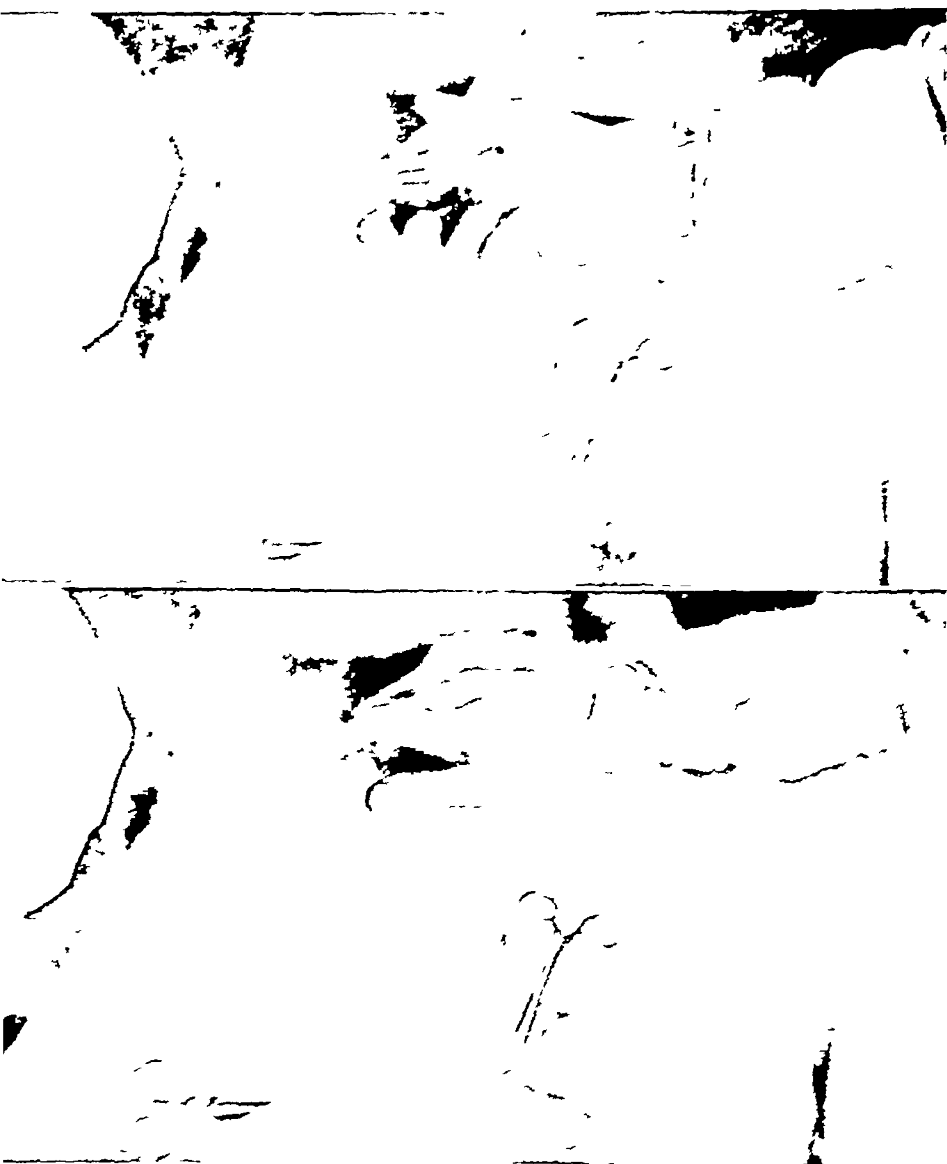


Fig 2 [illegible] For example [illegible] 2 [illegible]

has not really been accomplished until the last stitch has been inserted When the actual procedure is complete it is always worth having a look round to see that the field is clean and tidy especially inside the abdomen

Case Note Laparotomy was performed for a gunshot wound The bullet had passed dangerously near the second part of the duodenum and the hilum of the kidney but no damage was done Later the patient developed what appeared to be an ileus Eventually the abdomen was reopened and a coil of gut discovered bound down in the Pouch of Douglas by some organised blood clot If this favourite sump had been cleaned out at the time of the first operation a lot of heart burning might have been saved

In this case cause and effect followed close upon each other so that the relationship could not be missed Some times there is a longer interval and the connection between the oversight and the complication may be overlooked

Case Note A Hartman s operation was performed in an elderly woman for a carcinoma of recto-sigmoid involving the small intestine a length of which was included in the resection The patient did well for five years Then she developed an acute obstruction. A loop of gut had slipped through a gap in the mesentery

The medical protection societies cannot say how many swabs are left in the abdomen during an average year Many cases are never suspected much less reported but the total must be large

Case Note A patient with stones in the common bile duct had been operated on twice before for the same condition Last time healing of the wound took nine months On this occasion a hard mass as big as an orange was dissected away from the abdominal wall before the duct could be exposed. The mass contained a swab

In recent years the judicial opinion that a surgeon can rely on the swab count made by a sister or nurse has altered Certainly the routine question Are the swabs correct ? should be asked at the end of every operation

circuit rather than risk an extravasation of the infected contents by trying to free it" The plan is made beforehand and not while the gut is lying exposed Very often needless exploration can be avoided by a clear appreciation of the clinical situation It may happen, for instance, that a diaphragmatic pleurisy is mistaken for perforation of a duodenal ulcer At the onset the two sometimes give symptoms and signs which are not unlike and the surgeon may be trapped into opening the abdomen Finding the duodenum and gall bladder healthy and knowing that the signs were confined to the upper right quadrant, he can close the incision without further delay, to search for other pathological conditions in such a case would be to expose the patient to a quite unnecessary risk The surgeon who has not made a careful clinical examination would be considerably handicapped under such circumstances and even after an exhaustive search might complete the operation feeling that he had missed something

The abdomen is full of surprises and sometimes the preoperative diagnosis proves to be entirely wrong When this happens it is important to recognise things as they are, and not as it was thought they would be, even if a complete reversal of opinion is involved This may not always be as easy as it sounds, but it is one of the disciplines which the surgeon must acquire

Case Note A boy was brought to the theatre with a diagnosis of acute retro-cæcal appendicitis As he was being anæsthetised he passed a quantity of port wine coloured urine A specimen had been clear beforehand Now hæmaturia is not unknown in appendicitis, but this was hæmaturia of a different order, so the patient was sent back to bed without more ado, although no diagnosis could be made to explain the new circumstance He subsequently proved to have a ruptured kidney, caused by jolting his loin on the banisters

There is sometimes a temptation to lose interest once the object of an operation is accomplished, but in fact it

An Old Surgeon's Comment One man s experience of any particular operation is bound to be limited Even when his series of cases is bigger than any other it must still fall far short of all the others put together So he should never excuse himself by saying I have always done so and so nothing has ever gone wrong It will do if he takes the risk often enough Perhaps it already has done without his being aware of it A minor complication is not always traced to its source The symptoms subside of their own accord and no more is thought of the matter It is only the major complication that creates a real impression and even then its *fons et origo* may never be suspected

For my own part when a case goes wrong after operation I have seldom to look far beyond myself for the cause of failure—something done something not done This is a lesson hard to learn we blame persons things accidents and circumstances rather than ourselves

Thomas Keith 1873

In the practice of surgery where such cases occurred in which the operation proved inadequate he always investigated with uncommon attention the causes of that want of success.

Everard Home on John Hunter

When something goes wrong it is well worth while examining all the circumstances in the hope of unearthing the cause For oddly enough there is a reason for things going wrong as well as for things going right and if this reason does not become known it is quite likely that the same sequences of events will result in the same thing going wrong next time I have been unlucky enough to see two patients suffer the consequences of an identical anæsthetic error on two successive days solely because the cause of the first error was not enquired into

A carefully kept record of personal mistakes makes more profitable private reading than the most up-to-date text

but it seems at the moment that even when the answer is "Yes," the law may still consider that the responsibility has not shifted.

Every precaution against oversight must therefore be taken from start to finish of the procedure. A loose swab should never be left in wound or abdomen if this can possibly be avoided. With the attention concentrated on other and more absorbing matters it can easily be forgotten, and when the time comes to survey the field it may be so soaked in blood as to be indistinguishable from its surroundings, certainly to the eye and perhaps also to the touch. Packs, of course, must be left to look after themselves, but they should always have a tape attached and a forceps clipped to the end of it immediately they are put inside. Some packs are already provided with large metal rings at the end of the tape.

If a swab is reported missing no effort should be spared to find it; when the surgeon has completed a systematic search, his assistant should repeat it with equal deliberation; meanwhile the theatre staff will check and recheck their count, and, nine times out of ten, it is they who will prove at fault. If, after all this, it is still missing an X-ray of the part must be taken at the earliest opportunity—all swabs and packs should have a radio opaque inlay. When the worst happens and no trace of it can be found by any means full notes should be made of all the circumstances. They may prove invaluable in the after treatment. And if there is any litigation later on the judge will want to know all the details. He is likely to take a much more serious view of a complete oversight than of a loss accepted only after a thorough search continued until the patient's condition made it imperative to close the wound without further delay. Also he will regard good notes as prima facie evidence of work carefully carried out.

CHAPTER II

POSITION ON THE TABLE

MOST people are willing to put up with the likely and probable consequences of an operation or what they take to be the likely and probable consequences—discomfort pain chest complications and so on—but when a patient goes to the theatre to have his prostate taken out and comes back with a paralysed arm he is almost certain to suspect that someone has blundered

And yet in these cases it is not always easy to say who is at fault What s everybody s business is nobody s business and no one has bothered about the dangling arm or the twisted leg But in a well-organised operating team someone should always hold himself responsible for these matters and since the anæsthetist is most concerned with the position of the patient s trunk on the table it is right that he should also be the one to look after the limbs

It is not invariably an oversight that is the cause of the trouble The stereotyped operating positions—Trendelenburg lithotomy lateral—are sometimes to blame In their more exaggerated forms some of these positions throw such a strain on the joints and ligaments that a conscious patient would not tolerate them for two minutes The surgeon who has all the mechanical advantages of a modern operating table to minister to his convenience might ask himself What would the patient think of all this if he were awake?

To Prevent Paralysis A good general rule is to avoid as far as possible placing an unconscious patient in a position that a conscious patient could not endure If it must be done then the abnormal position should only be

book of surgery And this for more reasons than one, but perhaps the most important is that the same individual tends to make the same mistakes, or, at least, the same type of mistakes over and over again As soon as he becomes aware of this he can train himself not only to avoid the mistakes, but to recognise the occasions which produce them, and avoid them too These occasions of error are many and various, but most surgeons will confess to one that has to do with mood Now mood is a thing that rests between a man and his conscience, but one facet of it may be touched on here During the course of an operation it is fatally easy to allow small delays and difficulties to build up into something much more serious This should never be permitted Whether by an exercise of will power, or the simpler means of calling a halt in the proceedings for a minute or two, the surgeon must at all costs preserve the equanimities of himself and his team Osler regarded this state of mind as a first essential for every doctor Certainly it is a *sine qua non* in an operating theatre

Meanwhile we need not be discouraged by the number of things that *may* go wrong It is true that there are a great many pitfalls in surgery, but so there are in any other skilled occupation Yet the craftsman, as he gains experience, begins to find that he can afford to forget more and more of them, until in the end he ignores them altogether, and remembers only what he is about This is self confidence which takes most of the difficulty and all the hardship out of operating

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maintained for the absolute minimum of time But even with every care and foresight mishaps will occur It must be admitted that some of the mechanisms involved in the production of strain and paralysis are but poorly understood, so that it is difficult to take precautions that will cover every risk

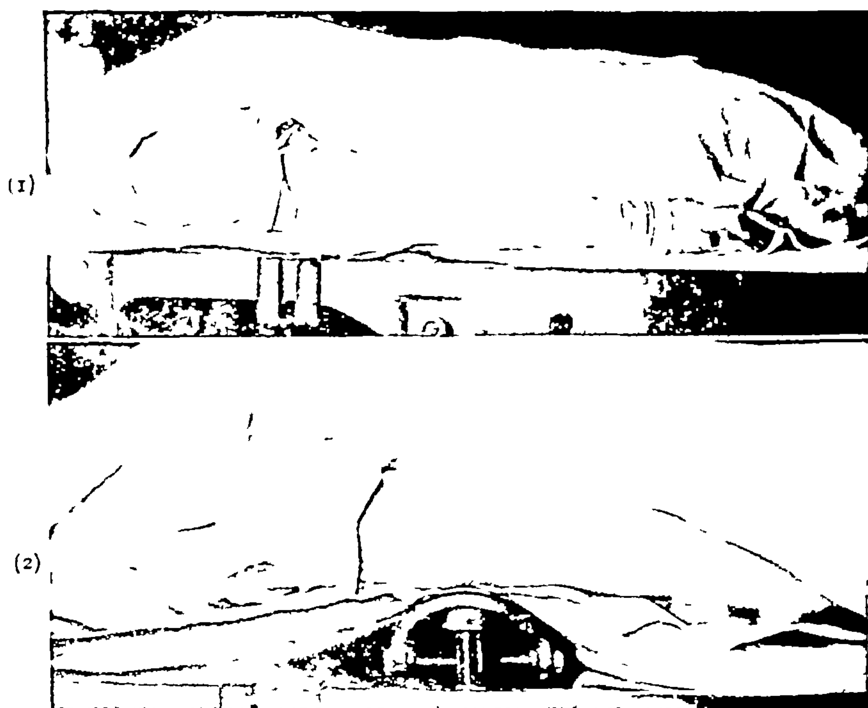


FIG 3 (1) The arm held safely in position under a roller towel (2) This is a dangerous position when the gall bladder rest is raised

The dorsal decubitus is the easiest and most natural position of all and it should be used as much as possible No risks attach to it so long as the arms are properly cared for They should be placed alongside the body with the hands lying flat and prone under the buttocks or held by a roller bandage which is placed on the table under the patient and folded back under itself after including the

forearms Sometimes this arrangement will not answer *e g* when the gall bladder rest is in use The arms may then be laid along the sides of the chest with the elbows



FIG 4 A safe position for the arms during an abdominal operation.



FIG 5 If the clenched hand is placed under the buttock the blood supply to the finger tips may be cut off the danger is greater with a heavy patient

resting on the table and the hands held by the up-turned nightdress

On no account should an arm be allowed to hang If it is almost any of its nerves may be paralysed by direct pressure or prolonged strain

The mysteries of the triangular outlet from neck to

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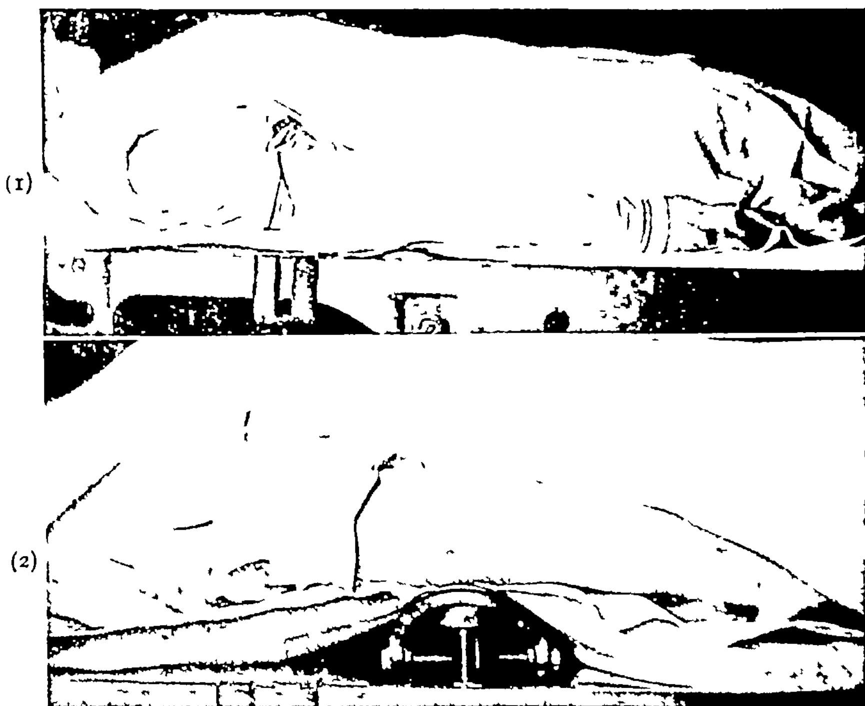


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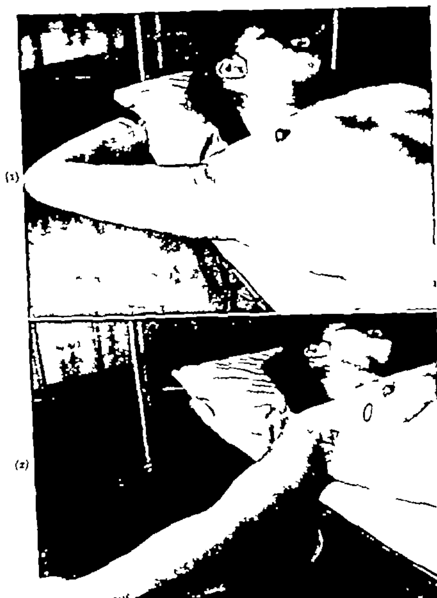


FIG 7 (1) Abducting the arm beyond a right angle throws a considerable strain on the brachial plexus. (2) A safe support for the arm during a radical breast operation. Notice that the position of the tumour is marked.

axilla bounded in front by the clavicle, behind by the scapula, and medially by the first rib, have greatly engaged the attentions of the orthopædic surgeons in recent years The frequency of the costo-clavicular syndrome in people who are up and about their affairs shows how easily injurious stresses and strains can fall on the nerves as they issue from the neck How much more likely is this to happen in a patient lying on an operating table with his arm fixed in some quite unnatural position for an hour or more while all protective spasm in the muscles is relaxed by a general anæsthetic or perhaps by curare

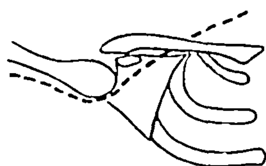


FIG 6 In the abducted position of the arm the cords of the brachial plexus are stretched over the head of the humerus

When brachial palsy followed a radical amputation of the breast it used to be thought that the weight of the arm dragging on the cords had done the damage Now it seems as likely that the trouble is due to over abduction of the arm which stretches the cords over the head of the humerus as they emerge from the triangular outlet (Fig 6) Abduction appears to play a big part in the palsies of this level, and it can do the same mischief whether the arm is abducted for dissecting the axilla or for some other purpose (Fig 7) Body slide due to Trendelenburg tilt aggravates the stretching in these cases, and many paralyses have followed major pelvic operations during which an arm was used for transfusion

The Trendelenburg position offers another threat to the brachial plexus if the whole body weight is thrown upon the shoulder rests and these are placed too near the neck So situated, they may press on the nerve of Bell, and the patient will be left with a Porter's paralysis This can be prevented by adjusting the rests over the acromion processes At the same time the tendency of the trunk to

pulmonary embolism amongst folk living in their own homes was traced to the use of deck chairs in air raid shelters the rails of which were instrumental in producing a thrombosis in the deep veins of the leg This suggests that ill-distributed pressure on the limbs during the course of an operation may harm other structures besides the nerves Perhaps the most dramatic complication of all associated with the Trendelenburg position is fracture of the femur caused by dropping the table end with the legs strapped to it when the patient is wrongly placed There can be no doubt that many of these accidents are due to the fact that the need for a Trendelenburg position is not



FIG 10 A pad to protect the ulnar nerve from pressure.

foreseen and when the surgeon asks for it unexpectedly during an operation both the patient s legs and the table are concealed by the towels so that no one can see exactly what is happening underneath

No matter what care is taken over the arrangement of the dropped legs part of the body weight should always be taken by the shoulder rests To rely on one without the other is asking for trouble.

Almost any departure from the horizontal dorsal decubitus introduces risk of injury to nerves In the lateral position the ulnar nerve at the elbow and the external popliteal at the knee (both easily compressed against bone) may suffer if the underarm and leg are not

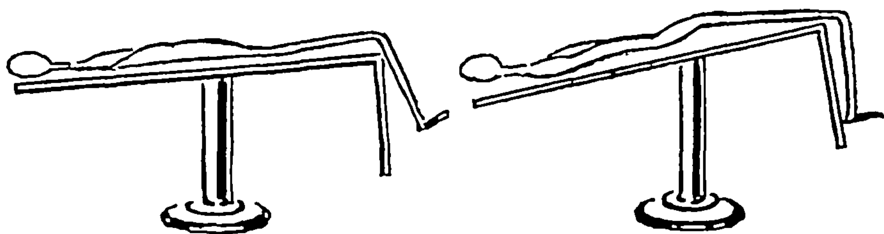


FIG 8 With the Trendelenburg tilt when the legs are flexed the sciatic nerve may be pressed on if the patient is too far down the table, and the calf veins may suffer if he is too far up The break in the table should correspond exactly to the flexure of the knees

slip down on to the rests can be discouraged by strapping the legs to the lower part of the table, which is then dropped to the vertical But this manœuvre carries its own drawbacks If the angle in the table does not correspond exactly to the flexure of the knees, or if the correspondence is exact but the padding is inadequate, the popliteal nerve may be exposed to pressure A similar form of paralysis is not unknown amongst people who have the habit of falling asleep in deck chairs One remembers also at the beginning of the last war that an epidemic of



FIG 9 Ankles supported to relieve the pressure on the veins of the calf and lessen the risk of thrombosis

An Unusual Complication of the Trendelenburg Position When the closing of a lower abdominal incision is completed while a patient is still in the Trendelenburg position air is likely to be trapped between the anterior rectus sheath and the peritoneum This may appear on the surface in the course of a day or two in the form of a surgical emphysema If the possibility of such a development is not known by the surgeon in charge of the case he may make a diagnosis of gas gangrene I have seen this happen

Stabilisation A patient lying on his side is never in a very stable position Something can be done to improve matters by *attention to the position of the legs* If the lower one is straight and the upper bent the tendency to roll forward is less and a true lateral position is maintained. If on the other hand the lower is bent and the upper staight the tendency is to slip into a semi prone decubitus This may be exactly what is required in some cases Either way sandbags will help to control movement and a Carter Braine rest for the upper arm will always discourage it Mention has already been made of the risks of built in supports on operating tables

Avoidance of Strain Abnormal posture throws a strain on other structures besides the heart and lungs The joints and ligaments resent acrobatics also especially in older people and are apt to harbour their resentment much longer than the respiratory system Lumbar strain is a not uncommon sequel to perineal prostatectomy carried out in the extreme lithotomy position A high gall bladder rest may cause considerable shock at the time and leave the patient with a backache for months afterwards What is more it may have served no purpose other than to make the operation more difficult

Case Note A cholecystectomy was completed with some difficulty because of the inaccessibility of the cystic duct and

properly cared for In the supine position one or other arm may easily drop over the edge of the table and remain unnoticed under the towels until the worst has happened Struts and supports on modern operating tables designed to increase stability may do more harm than good unless they are accurately adjusted

The Effect of Posture on Respiration and Blood Pressure In deep anæsthesia respiration becomes mainly diaphragmatic, or " abdominal " The Trendelenburg position interferes with this by throwing the weight of the viscera on the diaphragm In consequence the respiratory excursion is diminished, and the vital capacity lowered Not only this, but the venous return to the heart is hampered because the rhythmic suction of the inspiratory movement is less If a lithotomy flexion of the legs is added to a Trendelenburg tilt respiration is still further impeded This is the most cramping position of all Interference occurs also in the kidney position and when the patient is prone The effect of these adverse factors may become apparent at the time of operation, or not until a day or two later with the development of a pulmonary atelectasis Fat, elderly women are peculiarly prone to this complication Unfortunately they are the very subjects in whom surgical access is most difficult, and the temptation to tilt the table and use a super-abundance of packs is greatest when operating on them

If a tilt is really required during an operation it should not be exaggerated, and should be dispensed with at the earliest opportunity But the return to the horizontal should be gradual and not abrupt Under an anæsthetic, especially when there is any element of shock present, the vaso-motor system responds sluggishly or not at all to sudden demands made upon it, and a sudden change made nuder these circumstances may precipitate a circulatory collapse

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Case Note A cholecystectomy was completed with some difficulty because of the inaccessibility of the cystic duct and

artery On lowering the rest to close the wound, these structures came up from the depths to within easy reach The rest had been wrongly sited

It is sometimes the lifting and handling of a patient that causes the trouble Many a low backache dates back to clumsiness on the part of a nurse or porter When a patient is being shifted from trolley to table or back again, the people who do it should watch what they are about



Fig 11 The head is often forgotten when the unconscious patient is moved from table to trolley

When a patient is being turned over he should be turned as a whole and not by sections, and the underarm should be pulled through beforehand, neglect of the underarm has resulted in strain of the shoulder, paralysis of the plexus, and even fracture of the humerus

Position of the Surgeon In the operative-surgery class a good deal is made of the position the surgeon takes up at the start of an operation—between the arm and the trunk for ligature of the brachial artery, facing the sole

of the foot for a Syme s amputation and so on Marks may be deducted in an examination for any break with tradition in these matters but in the operating theatre a surgeon is allowed to suit his own convenience For most operations he will stand to the right of the patient perhaps changing to the left when he is dealing with something in the depths of the pelvis For operations on the perineum it is often best to have the patient in the lithotomy position and sit between his legs If the lateral position is used the surgeon should make up his mind beforehand which side he wants the patient to lie on Time is sometimes wasted through uncertainty over this

CHAPTER III

THE APPROACH

X-rays It is the practice in surgery to use a standard incision for an operation whenever possible, and this is a good thing since it enables the surgeon to perfect himself in that particular method But there is no reason why the siting of the incision should not vary with the requirements of the case One patient carries his stomach under his ribs, another almost in her pelvis , the kidney may lie well back in the loin or forward nearly as far as the iliac fossa For this reason it should be a routine to have any relevant X-rays displayed in the viewing box before the operation begins They will show at a glance the level of the lesion or the position of the viscus to be exposed, and the incision can then be made where it will give the easiest and most direct access Moreover, the X-rays can be referred to with the minimum of delay should need arise during the course of the operation

Skin Marking The use of Bonney's blue or some other skin marker is another aid to accuracy On the operating table there is nothing to indicate the side of a small hernia, and when large numbers of cases are being dealt with there is a temptation to rely on the house surgeon's not always reliable memory instead of consulting the notes Sooner or later a mistake will occur unless it is a rule for the nurse who prepares the patient in the ward to put a cross over the affected groin Small lumps in the breast are another source of trouble if precautions are not taken beforehand These may be quite awkward'to find without the patient's help Recently a surgeon was taken to court and had damages awarded against him for removing the

wrong lump But if the skin over the lump is circled round when it is being prepared there will be no opportunity for confusion at the time of operation The course of varicose veins can be plotted out in the ward too though this should be done by the house surgeon not the nurse Endless time is saved in the theatre by this simple



FIG. 12 The spot where pus was aspirated from the empyema is ringed with a circle in Bonney's blue.

precaution It is sometimes necessary to place a patient in a position on the operating table that distorts the normal relationships of the parts In a dissection of glands of the neck for example the head must be rotated and hyperextended to give good access to the anterior triangle Unless the incision has been marked in while the head is straight the scalpel may easily go astray

Lines of Cleavage in the Skin In 1831 Dupuytren was called upon to treat an attempted suicide at the Hôtel Dieu, one of the old Paris hospitals The police said that the patient had tried to drive a stiletto through his heart ,

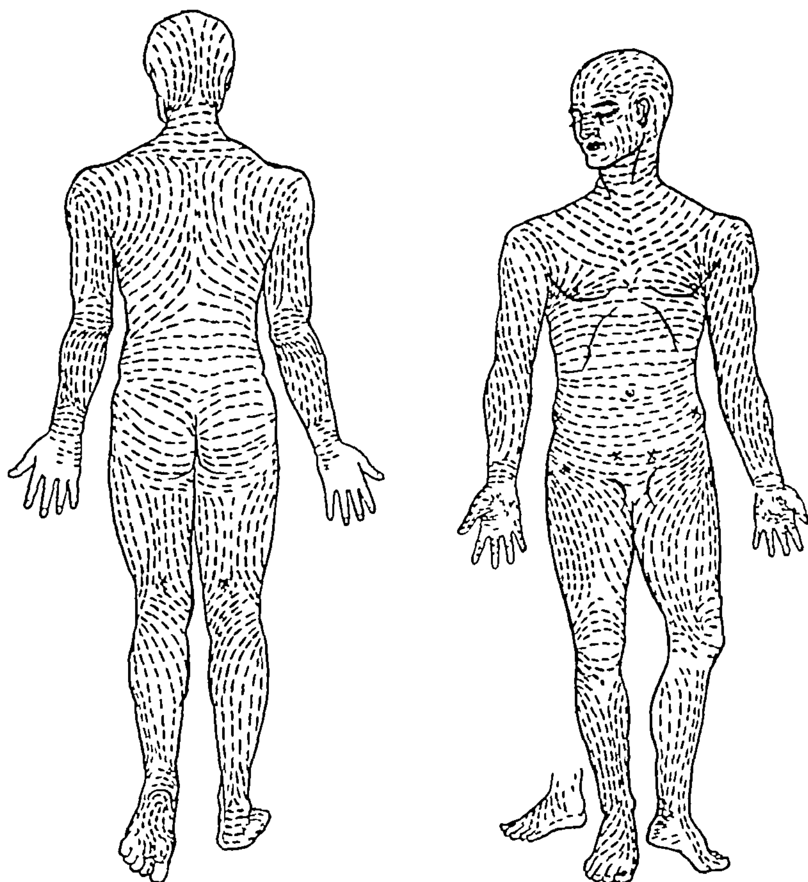


FIG 13 The cleavage lines of the skin H T Cox *British Journal o Surgery* (By courtesy of the editors and Messrs John Wright)

but Dupuytren noticed that the wound was linear instead of being circular as might have been expected from the shape of the weapon For this reason he became suspicious, but his suspicions were set at rest by experiments

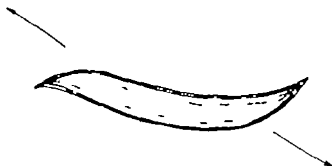


Fig 14 This kind of drag on a straight incision shows that the lines of tension have been crossed.

Fig 15 Contrast the healing of these two incisions. The one in the groin crosses the lines of cleavage the one below the knee follows them.

on a corpse, for he discovered skin punctures made by a conical instrument tend to elongate and that in any particular area the elongation is always in the same

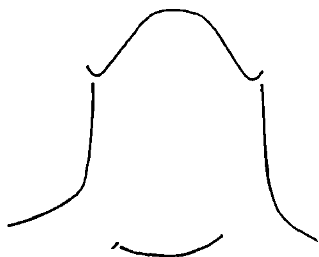


Fig 16 Transverse incision in the neck for a goitre operation There is a tendency to site it too low when the neck is extended and to slope it to the right, i e, downwards

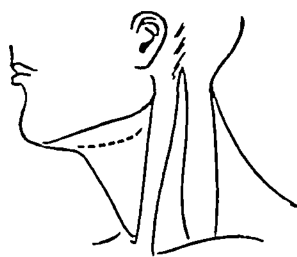


Fig 17 A collar incision for approach to the submaxillary gland

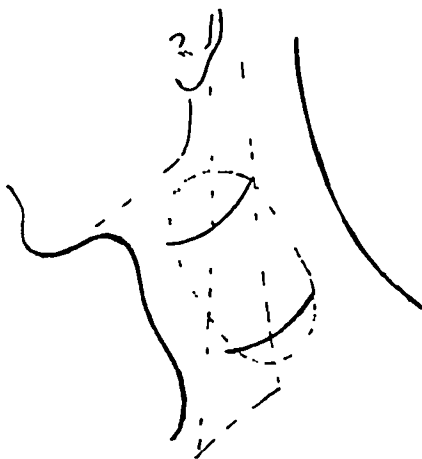


Fig 18 A large cyst in the neck can be approached through parallel incisions along the lines of cleavage

direction This was the first observation made on the cleavage lines of the skin Much later it was elaborated, and charts were drawn up to cover the whole body The phenomenon depends on the fact that connective tissue fibres in the dermis form lines of tension It is surgically

important because an incision made along these lines does not gape or go askew requires few stitches to bring it together heals with a fine scar and is unlikely to develop keloid In practice the need for good exposure often means that the lines must be disregarded but most



FIG 19 The temptation to slope a transverse incision downwards can be avoided by following a natural fold in the skin

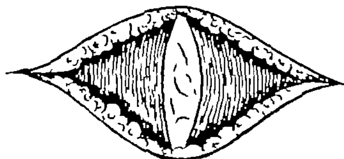


FIG 20 A transverse skin incision can be followed by a vertical separation of the muscles, *i.e.* in the neck, and in the lower abdomen

surgeons take them into account whenever it is possible to do so without interfering with the proper conduct of the operation For the neck back or front transversely disposed incisions are almost universally employed and the cosmetic results are usually excellent The gynæcologist and sometimes the urologist now take advantage of the suprapubic folds Even in the limbs the classic

longitudinal approaches are not as popular as formerly It is not, of course, obligatory to carry the incision straight on through the deeper layers By wide retraction of the flaps these can be split at right angles to the skin or at any convenient oblique

For the most part the lines of tension follow the flexion creases, but in front of the elbow and behind the knee and on the palms of the hands and soles of the feet the correspondence is not exact Their arrangement is remarkably constant in people of the same build

Flexion Creases Lines of tension have a bearing on the appearance of the part after operation, flexion creases on the function They are the more important of the two, and can never be ignored Incisions should be planned to run parallel to them or cross them obliquely, never at a right angle

Infections of the hand and fingers are commonly drained in a way that violates this principle The result may be a contracture not so very unlike a Dupuytren, or worse still a " starting " of the flexor tendon and permanent stiffness in the finger Palmar infections can nearly always be approached through transverse incisions The only satisfactory incision for a finger is the mid lateral at the easily seen transitional zone between the coarse dorsal and the fine palmar skin The incision sometimes recommended, halfway between anterior and lateral aspects, lies immediately over the vessels and nerve, and is therefore unsafe When an incision has to cross the finger it should do so at one of the transverse interphalangeal creases (Fig 116)

Transgression of a major flexion crease like the one in front of the elbow is likely to be followed by a particularly pernicious form of contracture No incision should ever be allowed to cross this fold If it is necessary to carry an exposure from arm to forearm it should be done by

making a wide detour to the inner side of the joint and reflecting the flap right across

It is not of course the presence of a flexion crease but the to-and fro movement occurring at right angles to it that stimulates the production of the fibrous tissue which leads to contracture later on So it is safer to keep any incision away from moving parts crease or no crease. After a radical breast operation for instance the upper

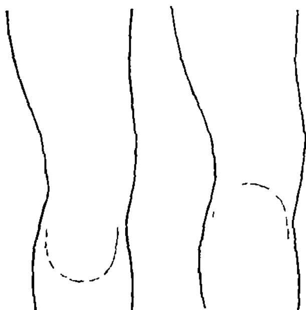


FIG. 2 The blood supply of a flap must be taken into account. Compare these two approaches to the patella.

end of the wound often occupies the position of the anterior axillary fold with the result that it hypertrophies and contracts when the patient begins to use her arm This will not happen if the original incision lies well over the pectoralis major and not along its outer edge

Another rule about incisions is that *they should not be made on surfaces exposed to pressure* An incision on the

pad of the finger or the sole of the foot is very apt to become tender and painful when use is restored In the finger a half "horse shoe" or two lateral incisions will drain a pulp abscess quite well (a complete "horse shoe" leaves an ugly furrow) In the foot all incisions should be lateral Amputation flaps must be planned to conform to the same rule This usually means a terminal scar, because modern prosthesis are seldom end-bearing but are designed to distribute the pressure before and behind

Surplus Skin. Surplus skin falls into wrinkles and these are difficult to keep clean and easily become the seat of intertrigo When a breast or superficial tumour is removed, therefore, the incision should include a sufficient ellipse of skin to forestall such a complication

Making the Skin Incision An incision in the skin should go through its vertical thickness for the full length of the wound without sloping one way or the other, and be completed in a single movement of the knife, repeated cuts are bound to result in bevelling of the sides and notchings of the ends

Care of Nerves A patient may complain of numbness in the neighbourhood of the wound after almost any operation, but it is seldom of consequence and soon clears up Sometimes, however, a neuroma may develop on a severed subcutaneous nerve, and the pain from this may be quite disabling Sometimes even the main nerves of the part may be damaged during the approach to a deep-seated lesion

Mishaps of this kind can often be prevented by planning the incision so that it avoids the nerves, but there are times when the only safe thing to do is to expose them deliberately and lay them aside, perhaps with their accompanying vessels, which may thus serve as a useful guide in the dissection A few examples of nerves that are endangered in the surgery of approach are given here—

there are many others

(1) The main trunk of the facial nerve may be cut if an incision is deepened between the mandible and the lobule of the ear The primary divisions may be damaged further forward when a parotid tumour is excised and the lower two branches may suffer during operations on the neck It is in order to safeguard these lower branches that neck incisions are kept at least an inch away from the angle of the jaw This is an example of planning an incision to avoid damaging nerves

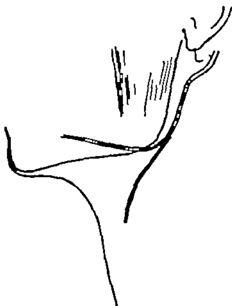


FIG 22 Relation of the lower branches of the facial nerve to the angle of the jaw The main trunk is very superficial in children.

(2) The dorsal nerves are endangered by thoracotomy In the standard method of rib resection they are deliberately laid aside Nevertheless they are sometimes cut during a clumsy operation even bruising of them may lead to an intractable neuritis The twelfth intercostal nerve may suffer while the kidney is being exposed The ilio-hypogastric and ilio-inguinal nerves come the in way of a grid iron incision for removal of appendix where they may be stretched or divided inguinal hernia often follows paralysis of the ilio-inguinal nerve A trans rectus incision inevitably deprives the muscle medial to it of its nerve supply Of all abdominal incisions the paramedian is the safest where nerves are concerned

(3) It is easy to cut the slender nerves of the hand if

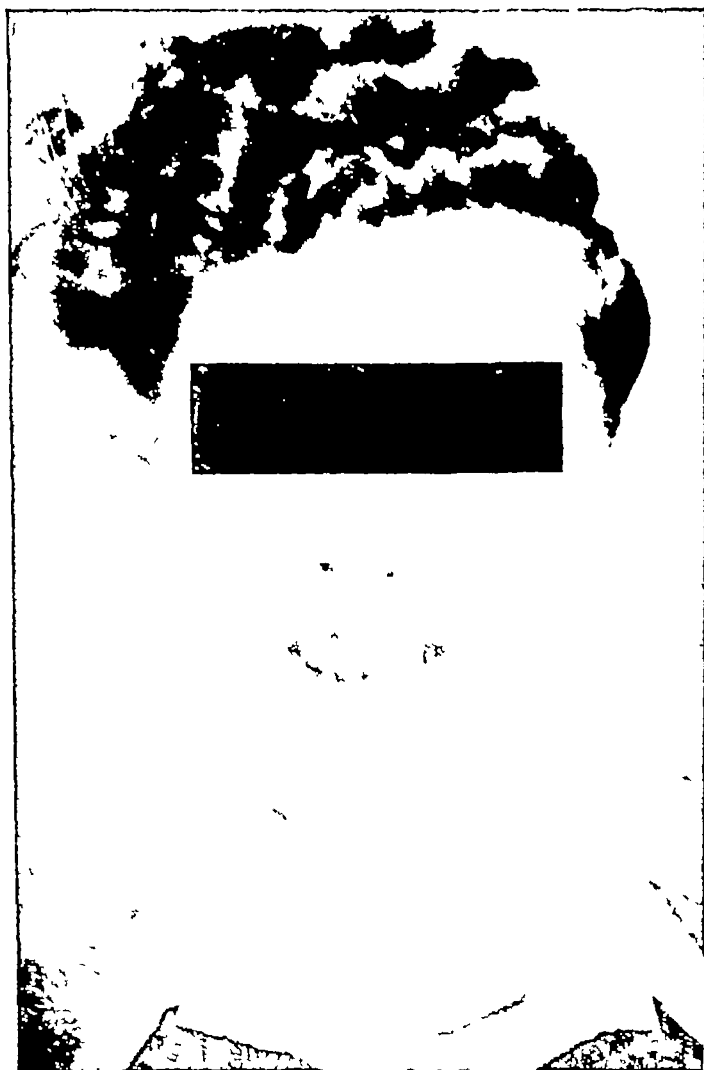


FIG 23 This patient had been operated on three times for an "abscess of neck" which eventually proved to be a branchial cyst Notice the weakness of the lower lip

they are not deliberately displayed the digital nerves and the twig from the median to the thenar muscles are particularly vulnerable The digital nerves are the eyes of the hand. Without them an object is unrecognisable by touch and a cigarette burn passes unnoticed Formerly when a whitlow was opened under a whiff of gas accidents were common

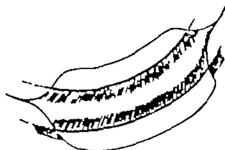


FIG. 24. Before a resection of rib the intercostal vessels and nerves are deliberately laid aside with the periosteum.

Nowadays with full anæsthesia and tourniquet control of hæmorrhage they should never occur The practice of careful dissection has saved many useful digits

In the Deeper Layers Unnecessary undercutting opens up tissue planes in which blood or exudate may collect and perhaps become infected later on It is therefore a thing to be avoided. The coverings of the body are generally sufficiently elastic to spring apart when they are incised without being undermined If they do not retraction is all that is needed to give the required exposure

Most of the standard approaches in surgery are planned to pass between muscles or groups of muscles or failing this to follow tendinous intersections in the substance of muscles In this way bleeding is minimised and repair is facilitated because the muscles tend to fall naturally into place afterwards where they can be anchored by sutures taking a bite of aponeurosis or sheath both of which are tissues that give a firm and durable grip

The paramedian incision in the abdomen illustrates these advantages very well No large vessels are encountered the posterior rectus sheath can be securely sutured at the end of the operation the muscle slips into

position of its own accord, and the anterior sheath is even more amenable than the posterior The classical Smith-Petersen approach to the hip joint can be quoted as another example The skin incision for this approach runs downwards and slightly forwards from the anterior superior spine of the ilium Then the tensor fascia femoris and the sartorius are separated to reveal the glutei behind and the rectus femoris in front These in turn are separated and the capsule of the joint is exposed No muscle is cut and the only vessel needing a ligature is a small branch of the external circumflex artery, which is easily identified In some operations the anatomy does not lend itself to a planned approach such as the ones just described Muscle intervenes between the surgeon and his objective and cannot be displaced to either one side or the other It must therefore be divided, but if it is possible to divide it in the direction of its fibres rather than across them this should be done for preference The muscle-splitting incision for appendicectomy affords an example In this the three layers of the abdominal wall are split each in the direction of its own fibres, so that not only are the consequences of transverse division avoided but the natural weakness of a wound is reduced to a minimum by the grid-iron effect

When muscle is cut transversely it bleeds a great deal from vessels which are often difficult to identify because of their inclination to retract , the bleeding from these vessels tends to diffuse before it comes to the surface , and it is not uncommonly dismissed as " only an ooze," when there is really a spouter underneath which will form an infiltrating hæmotoma unless it is dealt with

Muscle itself retracts too when it is cut, and it is not difficult to overlook its deeper layers altogether when the time comes for sewing up Even if there is no oversight and the full thickness is brought together no firm reliance

can be placed on the suturing because of the likelihood of cutting out The incidence of hernia after Kocher's approach to the gall bladder or the ordinary loin incision for the kidney is proof of this For these reasons muscle cutting incisions are better avoided whenever possible

Size of the Incision In dealing with an abdominal

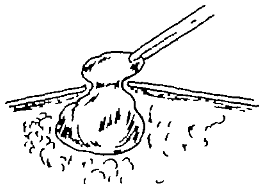


FIG. 25 It is sometimes possible to mobilise and coax out a soft tumour or cyst through quite a small incision

abscess or draining a viscus the incision should be as small as possible A large incision in the abdomen which becomes infected may be followed by a hernia and *will certainly interfere with* second stage procedures Incisions in other cases should err on the large rather than the small side but the surgeon should guard against *making a large incision and* using only one end of it With obese subjects an extra inch through the fat at either end is always advisable The deeper part of the incision need not be so extensive If a nick is made in the

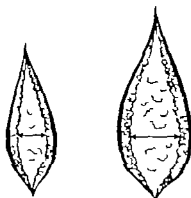


FIG 26. The longer the incision the wider it can be retracted, so carrying an incision down to the pubis may improve access to the flank.

posterior sheath and peritoneum at the suspected level of the lesion it can be extended up or down according to requirements and no further

In spite of every care it must sometimes happen that an incision is inadequate or wrongly placed In the limbs it can usually be lengthened with due regard to the anatomy of the part This applies to the abdomen also An extra half inch down to the pubic bone may make all the difference to a pelvic operation, or up to the costal margin where the lower end of the œsophagus or cardia are concerned, in the loin the cut can be carried right back into the angle below the last rib, taking care not to injure the nerve or vessels Lengthening a wound, of course, increases its retractability, and this increase can often be taken advantage of in the abdomen Sometimes, however, it still fails to give sufficient access to the flank The spleen, for instance, is not always easily reached in this way It can be exposed very satisfactorily by dividing the rectus transversely *through a tendinous intersection* When this is done there is no need to stitch the muscle to its sheath, the intersection prevents retraction so long as the incision does not go beyond it There are no intersections in the rectus below the umbilicus, and for this reason transverse incisions are better avoided at this level

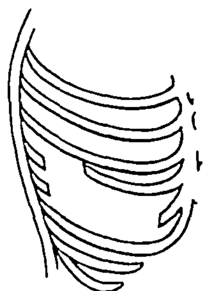


FIG 27 A thoracotomy approach can always be enlarged by resecting an inch or so of the next rib higher up posteriorly, then the anterior part of this rib can be retracted widely

When, as is bound to happen from time to time, a diagnosis proves to be completely wrong, and a condition thought to be lower abdominal turns out to be upper abdominal, it is usually wise to make a fresh incision, certainly it is a mistake to carry the one incision from ensiform to

pubis a bridge should always be left except in those cases (usually traumatic) in which it might be fatal to waste a minute.

The thorax is approached through an intercostal space or after resecting a rib In either case the surgeon is up against the difficulty that no matter how long the incision may be it is not retractable It can be made so by resecting a short length of the next rib higher up and if necessary of the one above that again This allows the remainder of these ribs to be pressed against each other so opening up the wound The same principle is applicable in the loin where the narrow cleft between the last rib and the iliac crest sometimes makes the kidney almost inaccessible without a rib resection

Through an Old Incision When an old incision is being reopened it is usual to start by excising the scar in the skin along with a bit more at either end These extensions allow the wound to be deepened where the anatomical details have not been disturbed and the various planes are still identifiable This done there is less difficulty in dealing with the intermediate part In the abdomen it is particularly important to adopt such a plan because bowel may be adherent to the peritoneal scar and may be damaged if this is cut straight down on without slipping a finger inside from above or below

A fresh incision should never be made parallel to a previous one If this is done the intervening tissue is deprived of its last remnant of blood supply and may quietly necrose leaving the patient with a ventral hernia

CHAPTER IV

HÆMOSTASIS

THE ligature was known in Roman times, but fell into disuse like many other things during the dark ages Ambroise Paré, a surgeon who worked with the armies that fought for France against the Austrian Empire during the sixteenth century, rediscovered it There is a panel in the Paris Ecole de Medicine showing him grasping a ligature in one hand while with the other he spurns the hot iron and boiling oil which were the only alternatives in those days Paré experimented with instruments for seizing vessels too, but it was not until the time of the Crimean War that Spencer-Wells introduced his forceps Without them the task of keeping the field dry during an operation must have been an almost impossible one No development since has improved on this simple and straightforward method of dealing with hæmorrhage

Nowadays hæmostasis is half of surgery The good surgeon controls all bleeding as it is encountered, not only to prevent blood loss (for an ounce saved is worth two ounces transfused later on), but in order to keep the field clear for the next step It is possible to judge at a glance whether he knows his job or not by the attention he gives to this matter Is the field of operation dry? Or is it soaked and are there stains on the assistant's gown? Or, worst of all, is there a pool of blood on the floor?

Small Vessels In any standard procedure, where the anatomy is well known, the forceps should be applied before and not after cutting a vessel In a herniotomy wound, for instance, the superficial epigastric vessels, being fairly constant in position, can be exposed and

picked up in two places before they are divided The tiny vessels which are displayed in a paramedian incision as they emerge from the medial border of the rectus offer another opportunity for intelligent anticipation if these



FIG 18 The first forceps has missed its mark, but it is used to demonstrate the bleeding point while a second is more accurately applied.

are cut before they are caught they retract within the muscle and must be under run with a stitch to stop the bleeding So too with the perforating branches of the internal mammary artery in a radical removal of breast If an intestinal vessel is not secured in advance it may slip out of reach between the leaves of the mesentery the

resulting hæmatoma may be exceedingly difficult to control, especially in a fat subject

When a vessel retracts, whether in subcutaneous tissue, muscle, or mesentery, the bleeding tends to diffuse, and come to the surface over an area There is sometimes a temptation to dismiss it as " nothing more than a general ooze " , but a general ooze more often than not means a bleeder underneath, although it may not always be possible to find it And the alternative consolation that the bleeding is " only venous " may be equally misleading, for veins sometimes continue bleeding a great deal longer than arteries

Some aural surgeons pride themselves on using only one swab to the removal of a tonsil Schoemaker, the great Dutch surgeon, used no swabs at all So skilful was his use of the Spencer-Wells that a dab with the cotton gloves which he wore over the rubber ones was sufficient to soak up any blood that escaped

The practice of cutting first and picking up afterwards usually means that unnecessary tissue is caught between the blades of the forceps with necrosis resulting later on, and sometimes the actual bleeding point is missed altogether When this happens the natural inclination is to remove the forceps and try again Instead it often pays to use them for keeping the tissue on the stretch while a second pair is applied more accurately

Crushing in the grip of a Spencer-Wells may be all that is needed to seal off the mouth of a small vessel This method sometimes serves for the distal end of a divided arteriole when the proximal end requires a ligature In the past some surgeons developed a special skill in the way they twisted the forceps of a vessel so that the lumen remained occluded without any more ado One gynæcologist is reputed to have been in the habit of doing a hysterectomy without tying off a single bleeding point

Nowadays we rely either on the coagulation produced by the diathermy current or on a ligature

If the diathermy is used the forceps held clear of all contacts except at its tip is touched with the electrode while the current which should be strong enough to produce a visible change in the tissues is thrown in by the foot control Diathermy coagulation saves a lot of time but it is not very reliable it is safer to use a ligature for a vessel of any size or even for a small one when it happens to be close to its parent trunk because the trunk might be damaged if the current were conducted back along the branch Oddly enough the theoretical objections to diathermy are strongest in the field where it is most often employed—prostatic surgery deliberately to create a slough in a surface exposed to infected urine is asking for trouble

The assistant who holds a forceps while a ligature is being tied should take care not to twist it out of its lie but even so the merely picking it up must displace the tissue within its grip to some extent If this tissue springs back into place as the forceps is released after the first hitch of the ligature closes down the result may be that the second hitch does not fall on top of the first One way of avoiding this fault is shown in Fig 29 If two points are ever included in the same ligature (and this is not safe unless they are very close together) the forceps should be laid beak to beak dead in line with each other

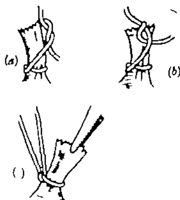


Fig 29 Common mistakes with a ligature. (a) The stump included in the second hitch. (b) Part of the stump included. (c) A safeguard. The assistant picks up the stump before the surgeon ties the second hitch.

before the first hitch is tied, otherwise the end of one or both may be included and the knot completely spoilt

Ligature material should match the vessel to be tied No 1 catgut is wasted on a small vessel moreover it will probably not occlude it Halstead, who devoted much

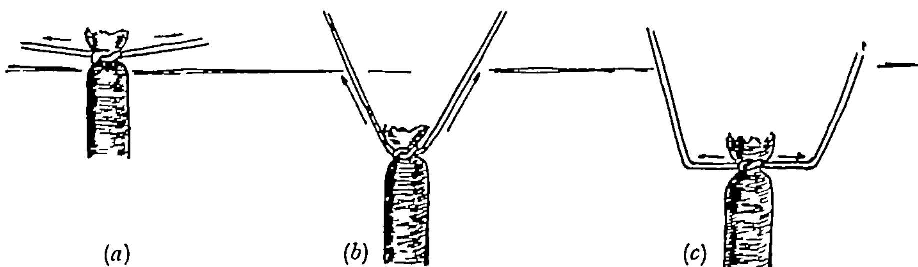


FIG 30 (a) An easy surface tie (b) A difficult deep tie, an oblique pull will snap the ligature if it is not a strong one (c) The oblique pull can be avoided by tightening the knot with the finger tips deep in the wound

time and thought to the problems of hæmostasis, believed that all vessels should be under-run with a threaded needle By doing this he considered the danger of slipping was avoided, and so the need for tight ligation eliminated It would take a great deal of time to under-run every bleeding point, but certainly this should be done when there is insufficient grip for an ordinary ligature

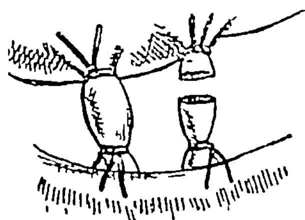


FIG 30A After ligating a vessel in two places it is divided close to the side to be discharged so as to leave as large a stump as possible This reduces the risk of slipping very considerably

There are vessels, most of them small and deeply placed, that do not lend themselves to control by forceps at all because they tear easily and are difficult to tie The thyroid veins and the cystic artery are obvious examples These are better under-run with a threaded aneurism needle and tied before they are divided Very minute bleeding points close to the skin should be dealt with

by crushing torsion or compression by a stitch ligatures give trouble when left so near the surface In the scalp vessels can be controlled without ligature by uniting aponeurosis and skin in two separate layers of closely placed stitches

Big Vessels When it is possible to ligate a big vessel in formal fashion (and this is not often) either artery forceps or aneurism needle may be used

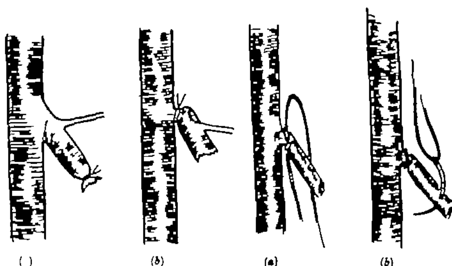


FIG 31 (a) The wrong way to ligate a tributary vein a cul de sac is left which may release an embolus, and a potential collateral escapes. (b) The right way

FIG 32. Transfixing a vessel (or duct) (a) With one stitch. (b) With two. Always transfix below the ligature never above

If forceps are used three are required the proximal to crush a groove to receive the ligature the middle to control hæmorrhage while the ligature is being tied and the distal to prevent reflux bleeding The vessel is of course divided between the middle and distal forceps leaving a stump sufficiently long to prevent the ligature from slipping

With an aneurism needle it is usually an easy matter to

under-run a vessel and tie it with two proximal ligatures and one distal before dividing This is a safer technique than the other because the whole business is in the surgeon's own hands and the risk of a mishandled artery forceps is eliminated Moreover, the ligation can be performed without damage to the intima, and this is very desirable in certain cases (see below)

Pedicles But many big vessels form part of pedicles These should be cleaned as thoroughly as possible before being tied, not only to give the ligature a closer grip, but as a precaution against including what ought to be left out, *e g*, the tail of the pancreas in a splenectomy Once the pedicle is clean there should be no difficulty in transfixing it (Fig 34) This prevents slipping, which is the main risk attending the ligation of a pedicle, but care must be taken to see that the point of the needle passes between the vessels and not through one or more of them, such a mishap might cause troublesome hæmorrhage, introduce infection into the circulation, or perhaps lead to the formation of an arterio venous communication later

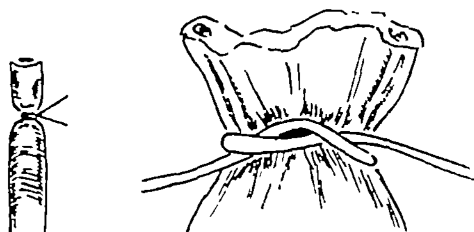


FIG 33 A vessel can usually be tied with a reasonably fine ligature, a pedicle requires a clumsy one which sometimes does not grip tight enough to occlude the vessel or prevent it retracting

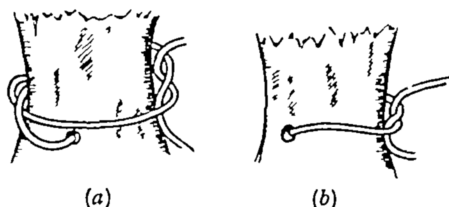


FIG 34 The ligature on a pedicle will not slip if it takes a bite, but encirclement must be complete (*a*) is a better method than (*b*)

on. On these occasions it is safer to use a blunt aneurism needle than an ordinary needle on a holder

Case Note A patient who had had his kidney removed six or seven years previously was found to have a loud bruit in his loin. At operation a varicose aneurism was found between the stumps of the renal artery and vein This was dealt with but the patient died of heart failure before he left hospital

When it is impossible to fine down a pedicle to reason

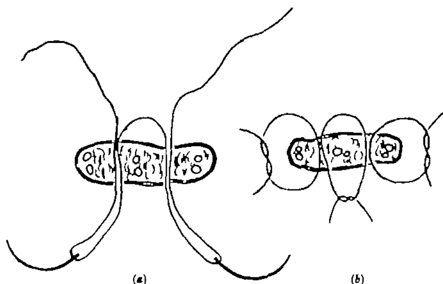


FIG 35 A method of tying a pedicle with a length of material and two needles to prevent slipping

able proportions special care should be taken to ligate it tightly Not only must hæmorrhage be safely controlled but the blood supply must be cut off completely from the protruding stump So exsanguinated it will undergo a process of anæmic necrosis and soon be absorbed altogether this explains why even the clumsiest technique in the removal of omentum seldom gives rise to trouble But if a stump retains a precarious nutrition it may become infected and slough or at best pass through a stage of hæmorrhagic necrosis before it disappears during

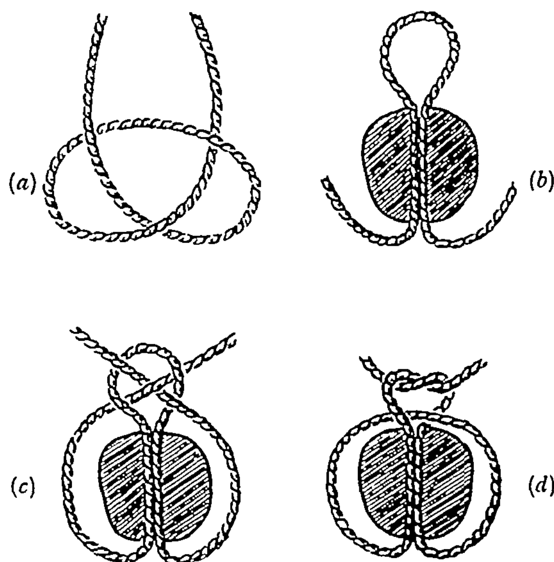


FIG 36 Three men were hanged together in Staffordshire with the same piece of rope The Staffordshire knot (*a*) can be used to secure a pedicle by passing a ligature through with an aneurism needle (*b*), and threading the ends through the loop so formed before knotting them (*c*), or reversing the loop over the stump of the pedicle and then drawing the ends through and knotting them (*d*)

which time it is likely to attract numerous adhesions, a most undesirable complication if it occurs inside the peritoneal cavity

A ligature will not bed itself in to a pedicle that is under tension During a nephrectomy, for instance, the renal pedicle is on the stretch as long as the assistant maintains his pull on the kidney, he must therefore relax a little as the knots are tightened, if he does not do this the ligature may come away altogether when the pedicle is divided and the stump is freed

Most pedicles are best tied about their middle so as to leave an adequate but not unnecessarily large stump When dealing with malignant disease, however, a pedicle should be tied and divided as close to its base as is compatible with safety, because there is always a chance that

it may contain an extension of the disease

Ligation in Continuity The examiner who wishes to test a candidate's knowledge of anatomy is as likely as not to ask him to ligate a vessel in continuity

Outside the operative surgery room the procedure has fallen into disrepute It was at one time employed in the treatment of intractable hæmorrhage but the vagaries of collateral circulation often interferred with the calculations of the surgeon and the results were disappointing Nevertheless the method still proves useful on occasion —as a preliminary to shoulder or thigh amputations when it might be awkward to ligate the main vessel on the stump or when there is danger of secondary hæmorrhage from an amputation carried out at a lower level or before operations on the tongue

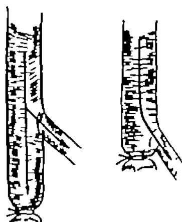


FIG. 37 A large artery should be ligated by its nearest branch so that the whole force of the bloodstream is diverted and none wasted on a cul de sac. It is always undesirable to leave a test tube of blood, open or closed. This invites a spreading thrombosis.

When there is no question of amputation as in an occasional case of aneurism the effect of ligating a large artery on the distal blood supply must be taken into account Simple ligation precipitates an intense vaso-constriction throughout the whole arterial tree If the artery is divided between ligatures the reflex arc responsible for this phenomenon is broken and vaso-constriction does not occur This then is the obvious safeguard Moreover it is a protection against the possibility that clot in the distal end may be dislodged by pulsation in the proximal

Until recently it was the practice of some surgeons to tie the vein as well as the artery in a doubtful case with

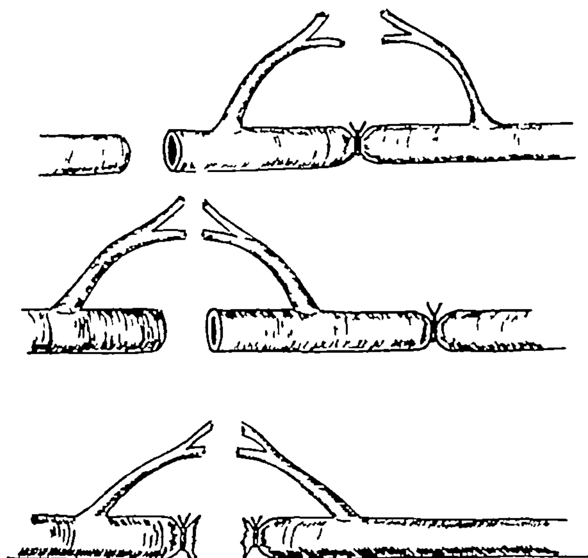


FIG 38 In one case a ligature in continuity will not stop bleeding because the collateral circulation opens up in another case a ligature in continuity will abolish the collateral circulation at the level of the lesion whereas local ligation is certain to stop the bleeding and will never interfere with the collateral circulation

the idea of increasing the distal blood pressure It is true that no harm results from tying a vein like the superficial femoral when the artery is intact, but when the artery is tied as well and the blood stream is deprived of its impetus and faced with an obstruction at the same time, stasis and œdema are bound to result There is certainly no justification for any addition to the ordinary operation if pulsation is seen in the distal stump of the divided artery When this is present the collateral circulation is assured

Here is a table (taken from official figures) of the incidence of gangrene following ligation in continuity —

Subclavian artery	0 per cent
Axillary ,,	14 ,, ,,
Brachial ,,	0 ,, ,,
Femoral ,,	17 ,, ,,
Popliteal ,,	26 ,, ,,

Recent experience suggests that these figures are much too low It goes without saying that all effects short of gangrene may develop—poor circulation muscular atrophy etc and that results are likely to be worse in old people than young When true ligation in continuity is performed certain rules must be obeyed. In the first place no other structure as for instance a nerve may be included within the ligature Southey in describing the loss of Nelson s arm said A nerve had been taken up in one of the ligatures and the ends of the ligature being pulled every day in hopes of bringing it away occasioned fresh agony There were no absorbable ligatures then and the plan of leaving the ends long was part of surgical routine It used to be thought that the best way of avoiding the misadventure just mentioned was to pass the aneurism needle *from* the adjacent important structure. Nowadays a safer scheme is adopted With a large vessel the sheath is deliberately opened and the aneurism needle slipped round inside it

The surgeon s next concern is to protect the coats of the artery from rupture To this end he gets his assistant to strip the vessel of its contents while he himself slowly and deliberately tightens the knot with his finger tips deep in the wound so that there is no tugging or displacement With an intact intima the likelihood of spreading thrombosis is diminished to the great advantage of the collateral circulation But anxiety to avoid damaging the coats of a vessel should never deter the surgeon from completely occluding it Partly to constrict an artery is asking for trouble

Incisions for Ligation of Vessels During the 1914–18 war two young French surgeons[1] working in a field ambulance found themselves dealing with a large number of arterial injuries Gradually they came to realise that

[1] Fiolle and Delmas.

the classical approaches were quite inadequate for the sort of work they had to do And no wonder These approaches have been copied from book to book without being tried out anywhere except in the operative surgery class, there being little occasion in civilian life for such operations on the living And even in the operative surgery class the object of the procedure was seldom anything more tricky than a ligation in continuity

The two French surgeons devised new methods, and after the war wrote a book, small but *très à propos*, describing them, and giving reasons for adopting them In brief, their argument was that while it may be practicable to ligate a great vessel in a cadaver through a classical incision, to attempt to do the same thing in a living subject who has sustained a gunshot injury is likely to end in failure if not in disaster In a wounded man, the operative field is infiltrated by blood clot, the anatomical points are grossly distorted, and fresh hæmorrhage may start at any minute For this type of work the most generous exposure is required to control bleeding, which may be as overwhelming as it is unexpected, to avoid injuring the nerves that run with the vessels, and to allow for errors in diagnosis, it being no uncommon thing to find the suspected vessel intact and the bleeding coming from another in the neighbourhood A skin incision the length of the arm or forearm, thigh or leg, is suggested as not unreasonable when trouble is expected

Free exposure is a principle that runs through the whole of traumatic surgery It is often as necessary in the abdomen as in the limbs

Rules for the Control of Hæmorrhage After the first war rules were laid down for dealing with primary hæmorrhage In brief they are —

(1) Always ligature a vessel that is still bleeding

(2) Ligature a large vessel though it may have stopped

bleeding otherwise it will start again when the blood pressure rises

(3) Ligature both ends if the vessel is completely divided so that bleeding does not recur from the distal end when the collateral circulation opens up If not completely divided but irreparably damaged divide and ligature

(4) When an important vessel is injured by a penetrating wound do not interfere for the time being unless gangrene threatens or the hæmatoma continues to spread. There may be sufficient flow through the vessel to nourish the limb until a collateral circulation is established After an interval any sequelæ in the form of aneurismal varix or varicose aneurism can be dealt with at leisure

Ligature Material. Some surgeons prefer thread to catgut for tying off small vessels It gives a closer frictional grip is non irritant and much cheaper Catgut is subject to too much variation in calibre consistency and durability to be entirely satisfactory It is wiser to select unabsorbable material for large vessels too to leave softening gut on a pulsating stump is running an unnecessary risk At the same time it must be admitted that many of the disasters attributed in the past to slipped ligatures were probably examples of secondary hæmorrhage Certainly we do not often see them since sepsis ceased to be the normal sequel of operation It is hardly necessary to add that when a vessel is tied in continuity a non absorbable ligature must invariably be used otherwise there is a good chance that patency will be restored as the catgut is absorbed.

Any structure embraced by a ligature inevitably undergoes necrosis When the structure happens to be an artery or vein and the right type of ligature has been selected for the job fibrosis keeps pace with necrosis and permanent obliteration of the lumen results but if a fine

ligature is knotted tightly around a large vessel it may cut right through, either on the spot or in the course of a day or two Or the cutting through process may be more gradual so that the lumen is re-established (Fig 39),



Fig 39. A ligature can cut through a vessel and allow the lumen to re establish itself

these risks are always greater after ligature in continuity than ligature after division The likelihood of trouble is considerably magnified where there is atheroma, arterio-sclerosis, etc The thickness of the ligature should there-

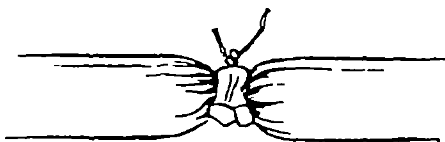


Fig 40 The main ligature round a large vessel anchored with a fine stitch

fore be nicely matched to the calibre of the vessel For really big vessels tape should be used in single, double or treble ligatures, so as to get the widest and smoothest apposition of the walls that is possible

Dangerous Hæmorrhage. Sooner or later every surgeon is called upon to deal with emergency hæmorrhage—from the renal pedicle, from the splenic pedicle, from the hepatic artery, or from a great vein An artery will nearly always contract and retract if given a chance, that is why a man may have a limb torn off in an accident and lose scarcely any blood on the way to hospital A vein is less obliging than an artery, and may often be the more troublesome of the two

The method of tackling a slipped artery when proximal

pressure cannot be applied to it is well established No effort should be made to pick it up until the wound has been packed for *ten minutes by the clock* At the end of that time contraction and retraction will have reduced the bleeding to a trickle The fatal error here or in any situation where packing is used for a similar purpose is to grow impatient and remove it too soon Nothing but further delay can result Once the bleeding—or most of it—is stopped it is an easy matter to pick up the vessel Sometimes the use of a ring or sponge forceps makes the task easier still The anæsthetist may now suggest that the sooner the patient is back in bed the better for all concerned If so the wound may be closed and the forceps left protruding from it Removal in three or four days will prove safe even with as large an artery as the renal because by then thrombosis will have sealed off the cut end. Sometimes indeed the emergency may be so great that it is wise to return the patient to bed with the packing itself *in situ* Should there be renewed hæmorrhage when it is taken out it may be replaced for several more days Any effort to pick up an individual vessel amongst the granulation tissue of this late stage would almost certainly fail But only in the very gravest of emergencies is it justifiable to leave either a forcep or packing within the peritoneal cavity

When a large vein is torn the table should be tilted at once—into a Trendelenburg position if the trouble is below the diaphragm into a reverse Trendelenburg if above (it is remarkable how helpful this manœuvre is when there is difficulty over ligation of the internal saphenous vein) Meanwhile packing is used again to stay the rush of blood until the field is clear Not uncommonly it may be necessary to enlarge the wound in order to get free access It has been said that the best instrument for dealing with hæmorrhage is the knife and no one can deny that a wide

exposure is very helpful in these tricky cases When the tear is clearly revealed it may be possible to stitch it up with oiled silk, a lateral ligature is liable to be pushed off and should not be relied on Failing this, the vein can often be tied above and below the level of the lesion The warning given above about fine ligatures on big vessels is pertinent to this procedure, in America accidents have been reported through neglect of it Patients have bled to death following ligature of the vena cava

I am indebted to a colleague for the following account of how he dealt with a tear in the vena cava which occurred during a nephrectomy It illustrates the tendency of *venous bleeding to persist*

Case Note The initial torrent was controlled by packing This was left for forty-eight hours When it was removed hæmorrhage recurred It was replaced At the end of another forty-eight hours the same thing happened On the third occasion a square of fascia lata was cut from the thigh and sutures inserted at each corner to act as spreaders This was applied to the bleeding area and wedged in position with more packing Next time there was no bleeding when the packing was removed, the fascia having become adherent

When a ligature slips or an artery forceps comes adrift during a cholecystectomy and there is profuse hæmorrhage, the chances are that the hepatic artery or its right branch is at fault, the cystic artery itself is quite small This is one of the places in which hæmorrhage can be checked by *applying proximal pressure* If the right edge of the gastro-hepatic omentum is compressed between a finger in front and a thumb behind in the foramen of Winslow the hepatic artery will be occluded and the bleeding controlled, while the vessel from which it comes is accurately picked up The manœuvre is greatly facilitated if the surgeon changes over to the left side of the patient and uses his left hand for compression leaving the

right free for picking up Any fumbling in this neigh bourhood may result in damage to the hepatic or even the common bile duct.

Secondary Hæmorrhage It is a tribute to the efficiency of his aseptic technique that secondary hæmorrhage seldom worries the general surgeon except in wartime But one of the necessary consequences of this is that he is often unfitted to deal with it when it arises As often as not in such an emergency his mind turns to thoughts of ligature in continuity and if he performs an operation of this kind he may either fail to stop the bleeding or find himself forced to amputate for gangrene

What is the best thing to do for hæmorrhage from a compound fracture of femur that has become infected? The only safe course is to *go straight for the bleeding point* So absolute is this rule that it includes first aid treatment The nurse in the ward who first sees the hæmorrhage is better advised to rely on direct pressure over the wound with pad and bandage than trust to the effect of a tourniquet

Later the actual source of the bleeding should be exposed It may be that by now the wound is dry Or if not the oozing will be seen coming from the depths in which no landmarks can be recognised amongst the granulations In either case the only course is to pack But every now and again it happens that the offending vessel is open to inspection Then—

(*a*) If it is the vein it should be laid open between ligatures

(*b*) If it is the main artery and not thrombosed light packing may be tried in the hope that the breach may heal and the distal circulation be preserved. But if it is thrombosed the affected segment must be excised between ligatures This gives the best chance of checking the spread of thrombosis There is some dispute whether it

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kidney no stitch is allowed to penetrate a calyx Some surgeons indeed prefer not to stitch the kidney at all and rely instead on encircling strands of ribbon catgut which are threaded through the capsule to keep them in place

With traumatic lesions of the liver the damage is sometimes of a kind that puts suture out of court Packing can then be tried and it may be that a piece of omentum will prove to be the best material to use

However confident the surgeon may be in his suturing of a viscus he should never neglect to drain Even if his repair is all that could be wished he must always reckon on the possibility of subsequent necrosis

Hæmostatics. In certain branches of surgery where perfect hæmostasis is essential ordinary methods often fail The neuro-surgeon for instance must use silver clips applied directly to a bleeding point in order to avoid the trauma that would be caused by Spencer Wells and ligature. But clips will not control oozing The plastic surgeon encounters the same problem as he completes an intricate reconstruction In delicate work of any kind an absolutely dry field at the end of the operation may make all the difference between success and failure It is in such circumstances after all focal bleeding has been stopped that hæmostatics may prove helpful if relied on to check gross hæmorrhage whether from the prostatic bed or elsewhere they will probably fail.

Clotting depends on two reactions which are represented thus —

Prothrombin + calcium + thromboplastin = thrombin
Thrombin + fibrinogen = fibrin

These substances have been isolated and put on the market in various combinations for local application and intra venous or intra muscular injection with the hope that their employment might shorten the coagulation

is better to bury the cut ends or leave them where they lie, probably the latter is the wiser course

Secondary hæmorrhage is due to infection, and *no effort to deal with it will succeed for more than a short while unless the infection is relieved* In nine cases out of ten this means that improved drainage must be provided

Hæmostasis in the Solid Viscera Most of the solid organs of the body, from thyroid to testis, are friable, and any prospect of repairing them depends on whether they have or have not a capsule strong enough to hold sutures

The spleen, besides being intensely vascular, has no capsule worth the name, and splenectomy is the only treatment even for a trivial tear The liver is better equipped The kidney still better But sometimes the capsule, as well as the parenchyma, is damaged by the injury In these cases some effort should be made to replace it with a bit of fascia, muscle, fat or peritoneum—anything that will prevent the stitch from biting into the parenchyma

Big vessels in a viscus should be controlled individually, arteries by ligature, veins by an encircling purse string suture But for the most part hæmostasis depends on adequate apposition of the cut surfaces Apposition is usually all that is needed Compression may lead to local necrosis or distant infarction For the same reason mattress sutures are better avoided The needle selected should be round bodied and of a size suited to the job required of it—that is to say, if should be large enough to reach the depths of the wound If it does not, a dead space may be left in which blood is liable to collect and later on become infected As a rule it pays to bring the needle out of one side of the gap before putting it through the other Supple catgut, size 1–3, is used, and the knot must be tightened with the utmost deliberation In the

application of Russel Viper venom will stop hæmorrhage but even such procedures have proved fatal

Another hæmorrhagic state which concerns the surgeon has to do with Vitamin K deficiency Vitamin K is obtained partly from the food and partly by bacterial syntheses in the bowel from which it is only absorbed when bile salts are present Deficiency is to be expected therefore when bacterial activity is in abeyance or bile is missing Chemotherapy conduces to the former condition and jaundice or biliary fistula to the latter All patients having sulphasuccinyl or sulphathalidine should be given additional Vitamin K by the mouth Jaundiced patients or patients losing bile through a fistula must be given it by injection

Anti-coagulants of one sort or other are nowadays becoming increasingly popular for the treatment of both medical and surgical conditions In surgery the question arises how soon after operation they may be used to prevent the spread of thrombosis Their use from the start as for instance after arterial reconstruction is very likely to give rise to troublesome hæmatoma formation The risk is even greater after procedures which leave an extensive raw area such as amputation of the breast or abdomino-perineal resection of the rectum In these cases an interval of three or four days is probably the minimum for safety

Another risk must be taken note of in connection with anti-coagulants and that is that a patient who comes to hospital for an emergency operation may be already under this form of treatment for some other complaint When this happens appropriate steps must be taken to restore coagulability to normal before he is operated on [1]

[1] The list of drugs that may queer the pitch for surgery increases steadily Patients taking cortisone for any reason need supplementary dosage when exposed to stress i e operation.

time Thromboplastin can be prepared from many tissues—brain, muscle, lung—and does in fact produce the desired result, the hæmostatic properties of a muscle graft are explained in this way But thrombin is more powerful still, and is now obtainable in a pure and sterilised form It can be used as a spray or powder Unfortunately, the clot so formed is easily washed away To prevent this happening the thrombin can be applied on fibrin foam, which tends to adhere to the oozing surface and is only slowly absorbed The rustic uses cobwebs as a hæmostatic dressing in much the same way Experiments are in progress with other absorbable materials that may serve a similar purpose—gelation sponge and oxidised cellulose

Clot and Clotting Every surgeon knows that bleeding from a tonsil bed often stops of its own accord once the clot is removed, so also with bleeding from a tooth socket Sometimes when a hæmatoma is evacuated even as late as a week after the injury, it will be found that bleeding is still going on in the depths

All this suggests that clot in some way interferes with clotting How it does so is not very clear, but, whatever the explanation, the phenomenon is certainly a strong additional argument for meticulous hæmostasis at the time of operation

Hæmorrhagic States That hæmorrhage is much more profuse and prolonged in some patients than in others is a commonplace But there are certain states in which this tendency oversteps the bounds of normality and becomes pathological Most important of these is hæmophilia The condition may be suspected from the history, but nowadays it can only be diagnosed for certain in the laboratory It is a contra-indication to all major surgery which is not absolutely essential to save life Minor operations may be justified in the knowledge that fresh blood or plasma transfusion combined with the local

CHAPTER V

THE ALIMENTARY CANAL

The Stitches The obvious way of joining one part of the gut to another is by a running suture which takes in the full thickness of the wall on either side and this is still the basic suture for most anastomoses but when surgeons relied on it alone they usually found that it failed to prevent leakage of intestinal contents so that many of their patients died of general peritonitis The credit for the good results of anastomosis which we see to-day and which we have come to take as a matter of course is due to Lembert He it was who pointed out that *inversion is a necessary condition for the healing of a wound in gut*

Inversion has two advantages —

1 It effectually prevents mucosal pouting

2 It brings smooth peritonealised surfaces into intimate contact. Because of the adhesive properties of peritoneum this is a most important factor in healing

The Lembert stitch inserted at the right angles to the wound (Fig 41(*b*)) gives the desired inversion in a very

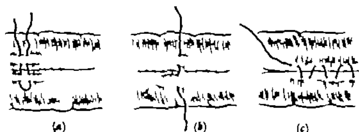


Fig. 41 (*a*) A Halstead suture. (*b*) A Lembert suture. (*c*) A Cushing suture All three are sero-muscular

simple and straightforward manner The Cushing (Fig 41(*c*)) and the Halstead (Fig 41(*a*)) are a little more

The Effect of Temperature. Warmth is a vaso-dilator and therefore increases hæmorrhage, but heat and cold are vaso-constrictors Hold a cut finger under the hot tap and the bleeding will stop It is heat of this order that is useful to the surgeon Wash-outs, douches, etc , should be at a temperature of 120° Fahr Hot packs should be wrung out of water at a still higher temperature A general surgeon does not make much use of cold applications, but an E N T surgeon sometimes finds an icy poultice laid behind the jaw will discourage bleeding from the tonsillar bed

Controlled Hypotension The blood pressure, and consequently the bleeding, in a part is affected, to some extent, by posture, and this effect is more marked when the vaso-motor system has been put out of action by a spinal or epi-dural anæsthesia Under spinal anæsthesia, for instance, the pressure in the legs can be halved by a Trendelenburg tilt The drug Hexamethonium achieves the same end by blocking ganglion cells, and can be used for operations on the head or neck where a spinal anæsthetic would not be applicable It is still necessary to deal with bleeding points, but these are few and far between, because clot forms quickly in the dilated vessels, and this becomes fixed when they recover their tone Nevertheless reactionary hæmorrhage must be watched for The method is helpful in certain plastic procedures, and provides an almost bloodless field for the aural surgeon's more delicate manœuvres, but it is not without danger of cardiac arrest or cerebral thombosis in older patients The anæsthetist who employs it needs to be specially skilled and experienced in its management

Hypotension can be induced by a variety of other drugs, either alone or in combination, acting at many different levels No doubt the future will eliminate some of them and establish others in common usage

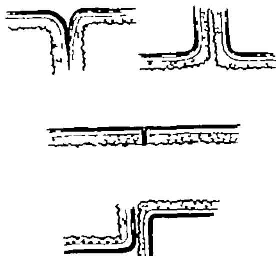


FIG 43 Four ways of bringing two pieces of bowel together of these only the first is likely to lead to sound healing

defective on one or other side of the anastomosis as it is when œsophagus is joined to stomach or colon to colon the union may break down altogether

But it is not only the adhesive properties of the peritoneum that are important In combination with muscle it forms a compact layer whose holding properties are almost of equal consequence When peritoneum is missing stitches tend to cut out Experimentally it has been shown that of two identical stitches one in the œsophagus and the other in the stomach the former will cut out under a pull of two and a half pounds while the latter holds up to four and a half



FIG 44 A Halsted suture picks up the tough submucosal layer and compresses the vessels

For these reasons extra precautions should be taken when dealing with the unperitonealised or semi peritonealised parts of the alimentary canal Of the intrinsic layers the submucosa is the toughest (Halsted considered it the only one of any importance and pointed out that it produced both sausage

complicated All three are used to reinforce an all-coats suture, in addition to bringing the cut edges together this suture has the important function of compressing their contained vessels, and can be trusted to check bleeding if these vessels are not too big The Connel suture (Fig 42(*a*)) combines the virtues of the inversion with those of the all coats, and may be used to replace both in an emergency when speed is a prime consideration

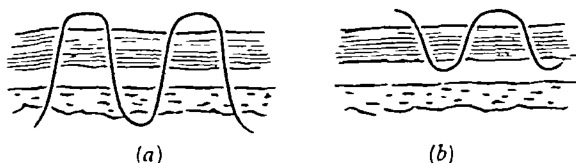


FIG 42 A Connel suture (*a*) goes through all coats, a Cushing (*b*) does not

Cushing and Connel sutures are continuous but the others may be continuous or interrupted A continuous takes less time to insert but it may cause puckering and constriction Moreover, if it is an all-coats suture its hæmostatic action may be undesirable in parts of the bowel where the blood supply is already exiguous, *e g*, the colon An interrupted suture is always kinder to the marginal blood supply, and in America it is preferred for colon surgery In this country we commonly use a continuous, but if it is an over and over, which is the most likely type to constrict, we control this tendency by introducing an occasional lock stitch

Part Played by the Serosa If, then, the peritonealised surfaces of two pieces of bowel are brought together uninterruptedly by sutures of any of these varieties union can be confidently expected If, on the other hand, the always redundant mucosa is allowed to pout anywhere along the future line there is a risk of leakage at this point (mucosal pouting produces the same effect anywhere, *e g*, the urinary tract) Worse still, if the peritoneum is

puckering but it should not be turned into a continuous lock (or blanket) which is neither hæmostatic nor water tight The clamps are now slackened to make sure that hæmorrhage has been completely controlled If there are still any bleeding points they must be under run The

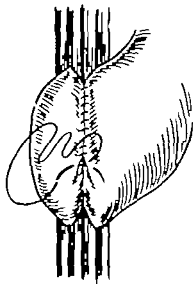


Fig 45 (a)

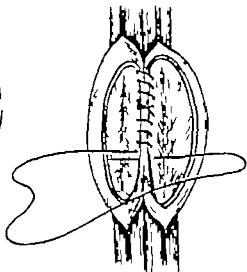


Fig 45 (b)

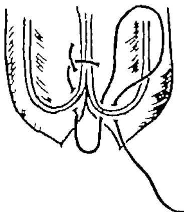


Fig 45 (c)

skins and catgut) A firm bite of this layer should be taken when peritoneum is missing Mattress sutures instead of ordinary are an additional safeguard against mishap Non-absorbable material may be used, but it must not breach the mucosal surface But *the best safeguard of all is complete absence of tension* When there is absolutely no tension there is no risk of cutting out, no matter how frail the union Unfortunately, however, tension may be produced by muscular contracture, though the parts are quite slack when at rest

Technique of Gastro-enterostomy The actual technique of anastomosis is subject to many minor variations Some surgeons use a Connel stitch instead of a Lembert, others a Cushing, though the principle of inversion is accepted by all Details of these procedures can only be learnt in the operating theatre, but diagrams are given here to suggest the successive steps Gastro-enterostomy in partial gastrectomy is taken as exemplar

Fig 45 (*a*) shows an ordinary right-angled continuous Lembert suture of No o twenty-day chromic catgut on a curved atraumatic needle, knotted a couple of inches from its end, which is left long, not only for tying off later but to mark the exact point where the suture started, and where it must end, if it is to complete the circuit and prevent any possibility of leakage It is inserted thereafter at intervals of $\frac{1}{8}$ inch to unite the unopened stomach and jejunum When this line is complete incisions are made down to the mucosa of the jejunum and on both sides of the stomach All gastric vessels thus exposed are picked up and tied off An additional guarding clamp is applied to the stomach, the mucosa proximal to it is divided with scissors, and the resected part discarded The jejunal mucosa is opened, and the posterior all layers suture of twenty-day chromic catgut on a straight needle is inserted This over and over continuous suture is locked occasionally to prevent

It must be admitted that this procedure is a complicated one but it is well worth mastering because it can be used with minor modifications for anastomosing almost any parts of the alimentary canal As has been said the full technique can only be acquired by watching and assisting at innumerable operations but the tyro may find it easier

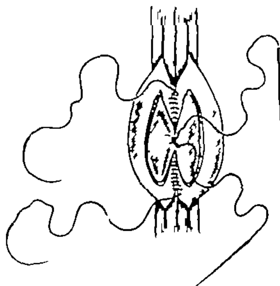


FIG 47 In order to keep the knots away from the dangerous angles at either end of the anastomosis some surgeons like to begin the suturing in the middle this involves the use of four needles.

to grasp the basic idea if he remembers that in gastro-enterostomy the posterior half of the outer suture is inserted first then the whole of the inner suture and then the anterior half of the outer This order is followed in an ordinary anastomosis of gut but not in the aseptic variety

Resection and Anastomosis of Gut. Certain facts about resection of gut are universally accepted —

(1) Resection is often needed for obstructive conditions but it is better avoided whenever possible until the obstruction is relieved and immediate anastomosis

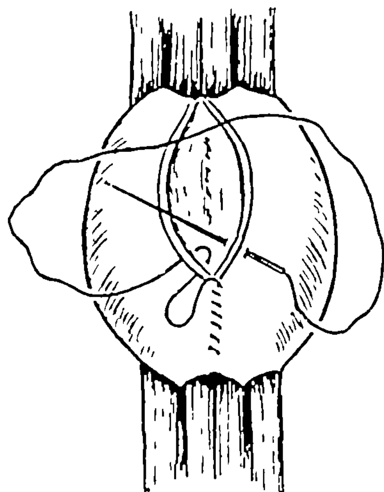


FIG 45 (d)



FIG 45 (e)

FIG 45 A technique for gastro enterostomy Details are given in the text Ends of sutures left long are omitted for the sake of clarity

return journey is begun by passing from within out on one side and from without in on the other (Fig 45 (c)), and continued as a Connel which is knotted to the original end left long (Fig 45 (d)) Each loop should drop vertically and the knots should lie on the mucosal surface

The Lembert is now completed (Fig 45 (e)) If there are any mucosal poutings these must be oversewn

When there is any question of delayed healing, as in a patient debilitated by prolonged vomiting or repeated hæmorrhage, the anastomosis should be reinforced by a series of interrupted non-absorbables superimposed at back and front

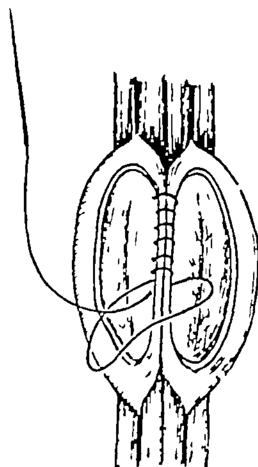


FIG 46 A lock stitch

accuracy of suturing These drawbacks however cannot be avoided when dealing with the recto-sigmoid

(3) In the actual resection the mesentery should be divided first not only because this can be done aseptically in contrast to the remainder of the operation but because the distribution of its blood vessels determines how much gut may be removed

(4) The arterial pattern should be studied in each individual case Variations are too common for any reliance to be placed on anatomical descriptions Rule-of thumb surgery is dangerous

(5) Colon is far more treacherous than small intestine Its blood supply is uncertain its peritoneal coat is incom plete and its contents are infective

(6) The slightest post operative distension after an anastomosis may spell disaster It is therefore wise always to provide some kind of safety valve for the con tents of the gut to escape through and this will usually take the form of a cæcostomy



Fig 48A. Mesenteric vessels should be deliberately exposed and ligated separately

A typical resection of small gut goes on the following lines The gut is delivered and the extent of the resection decided on The vessels (identified if necessary by trans-illumination) are isolated and secured this must be done deliberately so that they have no opportunity to retract (Fig 48A) A V is now cut in the mesentery Protective packs being arranged to isolate the field of operation and a red danger towel laid out for soiled instruments two crushing clamps are applied to the bowel in such a way that they continue the lines of the V The gut is divided close to the crushing clamps after guarding clamps have been placed on either side of them to prevent escape of

should only be embarked on when there is no other conceivable alternative There are several reasons for this apart from the obvious one that the patient is not in a fit state to stand a big operation For one thing the upper end of the gut is dilated and the lower collapsed, so that it is difficult to anastomose them satisfactorily Then the walls of the dilated end are friable and will not hold sutures Again the contents of the obstructed part are highly infective, peritonitis may easily result from the slightest leakage And so on Proper preparation is therefore essential, and this may take the form of drainage

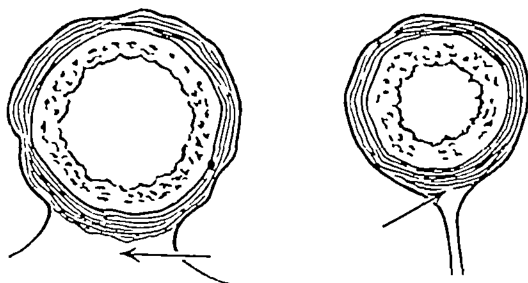


FIG 48 Compare the size of the dangerous unperitonealised angle in (*a*) the colon, (*b*) the small intestine

by means of a Miller-Abbot tube or a preliminary cæcostomy in the acute case, or a period of dieting, wash-outs and chemotherapy in the chronic, but in neither is it safe to embark on any major procedure unless the gut is *clean and empty*

(2) A coil of diseased gut should always be brought *outside* the abdomen before any attempt is made to remove it, this can be done quite easily with small intestine, but colon must be mobilised by incising the peritoneum on its outer aspect and stripping the bowel inwards until it can be delivered To venture on a resection inside the abdomen means that inaccessibility will multiply the chances of soiling and interfere with the

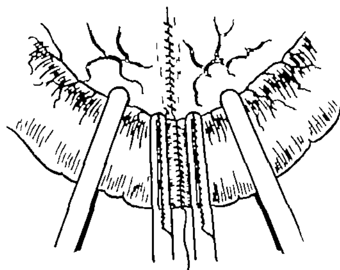


FIG 50 (b)

contents (Fig 50(a)) An oblique section leaves a wider lumen than a transverse one for the anastomosis and so diminishes the risk of subsequent narrowing In addition it serves to safeguard the marginal blood supply which depends on vessels that run circumferentially without inosculation (Fig 49) If the cut edges show a healthy pink colour with pulsating or better still spurting vessels their viability is assured When the diseased loop is out of the way the crushing clamps can be brought together the gap in the mesentery closed and the ends of the bowel united by the posterior half of the sero-muscular suture (Fig 50(b)) The crushing clamps are now removed and the crushed edges of bowel teased out and joined by an all-coats suture which begins posteriorly and continues anteriorly as in gastro-enterostomy (Fig 50(c)) Then the anterior half of the sero-muscular suture is completed The crushed edges slough into the lumen in due course but not before healing is well advanced. Notice that crushing clamps are never used on bowel that it is intended should survive.

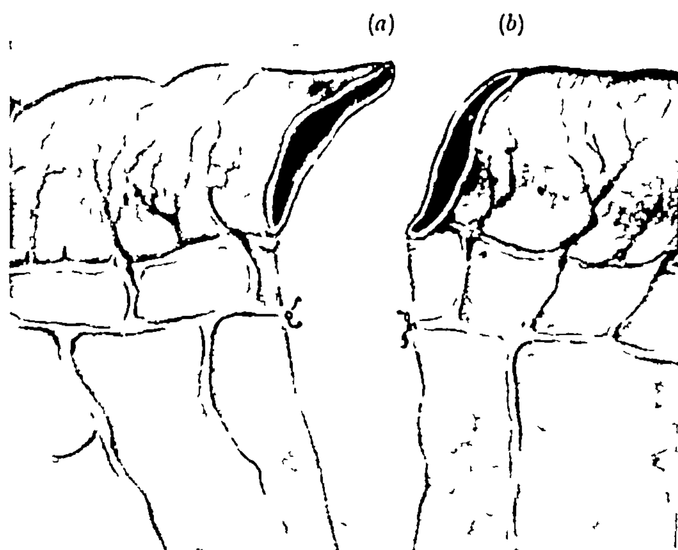


Fig 49 When bowel is divided obliquely the angle (a) may be deprived of its blood supply the angle (b) is perfectly safe

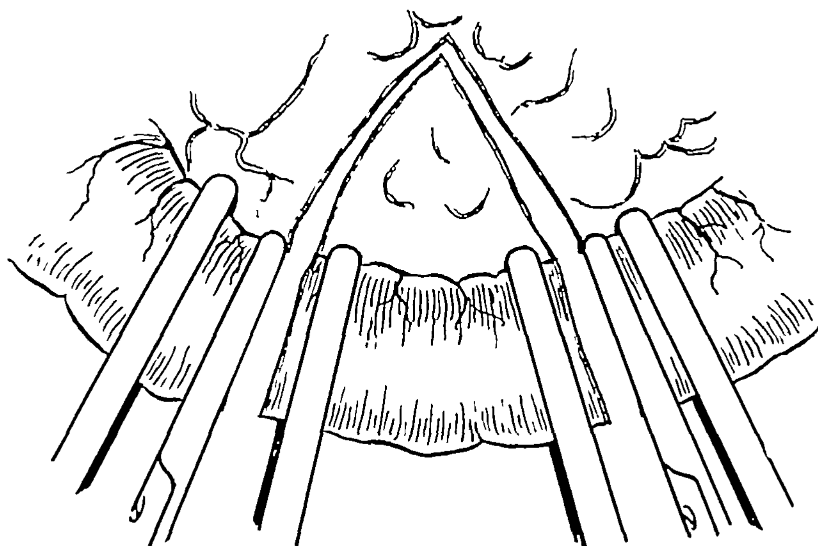


Fig 50 (a)

In practice it will be found that the mesenteric angle is the most difficult to close securely and it is at this point that leakage is most likely to occur An extra safeguard is suggested in Fig 51 Alternatively the two lines of suture may be started at the anti mesenteric end instead of the mesenteric This avoids adding the weakness of the knots to the weakness at the angle

Some surgeons condemn the crushing clamp and use light guarding clamps only or carry out an open anastomosis without any clamps at all a procedure that can

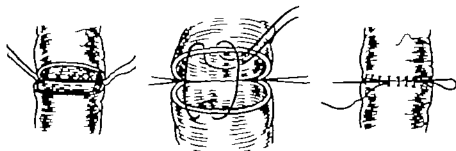


FIG 52 Intestinal anastomosis by interrupted suturing and without crushing clamps. Details are given in the text. The final sutures are not shown for the sake of clarity

only be justified when the bowel has been very thoroughly prepared Others prefer interrupted suturing to continuous because it interferes less with the blood supply and cannot narrow by purse stringing The sutures are inserted between stays which serve to keep the cut edges of the bowel on the stretch and the lumen wide open (Fig 52) Each suture of course requires its own knot and knots are apt to set up irritation especially when there are a great number of them to overcome this objection all knots are tied on the mucosa so that when the buried part of the suture is dissolved the knot is thrown off and got rid of The last few sutures present a difficulty but this is surmounted in a rather

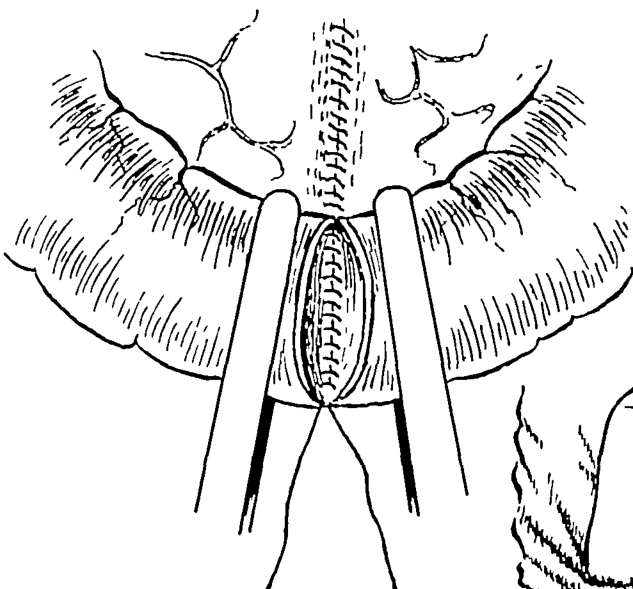


Fig 50 (c)

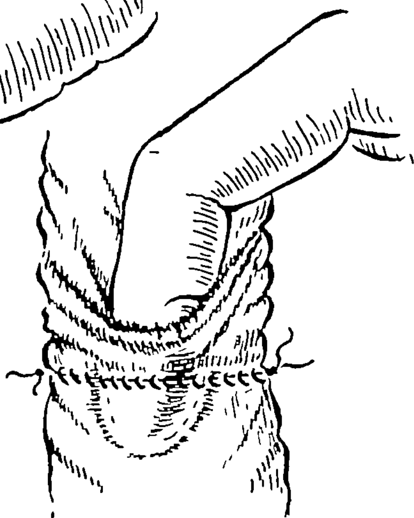


Fig 50 (d)

Fig 50 Resection and anastomosis of gut Details are given in the text The ends of sutures left long are omitted for the sake of clarity

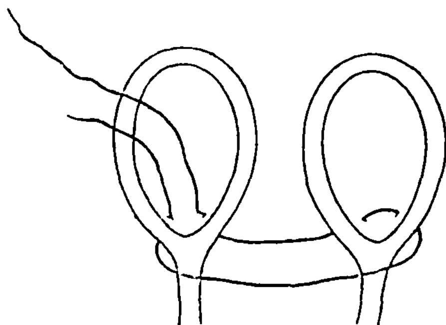


Fig 51 Intestinal anastomosis By starting the all-coats suture in this way the dangerous angle where the mesentery diverges can be effectively closed Alternatively a separate suture can be used for this purpose

much care is taken over an operation of this kind it can never be absolutely aseptic In the upper part of the alimentary tract this does not matter very much because the contents are sterile under ordinary circumstances (*i e* when the gastric secretion is normal and there is no obstruction) and soiling by them will not lead to infection Not so lower down The colon is always a potential source of infection and becomes a veritable plague centre when obstructed In planned surgery the risks are almost eliminated by the use of such drugs as sulphasuccinyl but there are occasions as in dealing with a gangrenous loop when the surgeon may find useful methods of anastomosis which though not 100 per cent aseptic nevertheless eliminate all possibility of intestinal contents escaping during the procedure

This type of aseptic anastomosis can be carried out in several different ways but the object in all of them is the same—*to unite the two ends of the bowel before the lumen is opened* When fine bladed crushing clamps are used the gut is divided close up to them with the diathermy needle they are then placed side by side and union effected with two Cushing stitches which are pulled tight as the clamps are withdrawn and their ends knotted together a Lembert follows (Fig 54) Or alternatively each end of the gut can

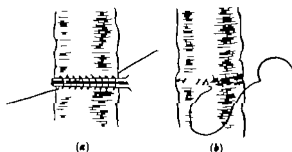


FIG. 54 Aseptic anastomosis ( ) The ends are united by a Cushing suture over fine-bladed clamps (*b*) The clamps are withdrawn and the anastomosis completed by a Lembert suture Hæmostasis is imperfect, but this seldom causes trouble

ingenious way When the suturing is nearly complete a threaded needle is passed eye first through the far side of the anastomosis to emerge from the remaining gap, the ends of the last few sutures are slipped through the loop and the needle withdrawn carrying them with it, they are then pulled tight, knotted, and allowed to retract within the bowel, all knots are now on the mucosa (Fig 52)

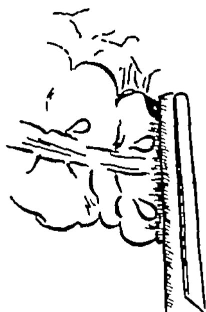


FIG 53 In preparing an end of bowel for anastomosis, care should be taken not to snip off an appendix epiploicæ containing a diverticulum, and the blood vessels in the extreme edge of the divided mesentery should be meticulously preserved

With certain modifications this method is well suited to resection of the recto-sigmoid colon The bowel, being divided above, the upper end is anchored with three or four sutures to the posterior aspect of the mobilised rectum, to which no clamp is applied The rectum is next cut across with scissors, and a posterior layer of interrupted thread sutures inserted between lateral stays Owing to the depth of the parts it may be convenient to insert all these, leaving the ends long, and then tie them all off together The anterior layer of sutures, looped on the mucosa to secure inversion, followed by three or four superimposed mattress sutures, complete the anastomosis

In anastomosing the colon particular care should be taken not to let any fatty tags intervene between the suturing At the same time the blood vessels in the extreme end of the divided mesentery should be meticulously preserved, and appendices epiploicæ should not be snipped away These may contain diverticulæ and even when they do not will prove extremely useful for protecting the anastomosis externally

Aseptic Anastomosis It is obvious that no matter how

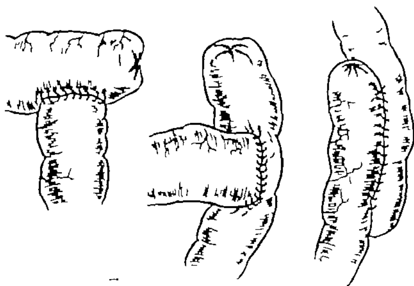


FIG 55 Side to end end to side and side to side anastomosis.

of the mesenteric suture may be made to take a bite of the sero-muscular layers of the bowel and so close the defect equally well So wide is this bare area in parts of the colon that end to-end union is better avoided altogether and end to side or side to end or even side to side employed instead The difficulty of dealing with one dilated and one collapsed end as in small gut obstruction

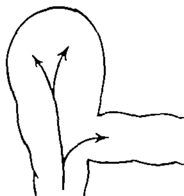


FIG. 55A. The consequence of leaving a proximal blind end.

be sutured over a clamp by a Cushing stitch with ends unknotted and left long Because of its continuous and parallel arrangement a Cushing stitch can always be drawn tight by pulling on both ends, or taken out altogether by pulling on one It is now drawn tight while an assistant slips the clamps out under it This inverts and *closes* the end of the gut (Fig 56(*a*)) The two closed ends are then united by another Cushing stitch followed by a Lembert Then the first Cushing stitches are pulled out, and lumen opened up by invaginating a finger tip into it from one or other side (Fig 50 (*d*)) Whatever method of anastomosis is used, septic or aseptic, this last manœuvre is advisable to prevent diaphragm formation and consequent narrowing

It will be noticed that with both the techniques for anastomosis just described the entire inner suture is completed before the outer is begun , this is accomplished by working first on one side of the bowel, then on the other Contrast gastro-enterostomy There is another important distinction In a gastro-enterostomy the inner suture is inserted from inside in aseptic anastomosis it is inserted from outside like the outer , care should be taken, therefore, to see that it penetrates at least as deeply as the submucosa in order (*a*) to get a good grip, and (*b*) secure hæmostasis One of the drawbacks of these procedures is that they tend to leave a considerable internal flange which predisposes to stricture , this flange should be kept as small as possible by suturing close to the cut edge Hæmostasis is not as certain as with open methods, but this does not seem to matter in the intestine

Risks of Infection There are other risks of infection besides those run at the time of the operation Even in the well-peritonealised small intestine the dangerous angle where the two leaves of the mesentery diverge remains as a weak point in the healing process The Connel stitch is often used to close this angle (Fig 51) , or the first loop

can be side stepped in the same way With these methods there are one or more ends of bowel to close permanently To do this the end may be crushed and ligatured at the site of crushing the ligature being buried with a purse-string suture. This plan works well for small intestine For colon it is safer to insert a Cushing stitch over the clamp tighten this when the clamp has been withdrawn and then bury it with a Lembert (Fig 56)

When all is said and done the element of uncertainty in anastomosis can never be quite got rid of Therefore

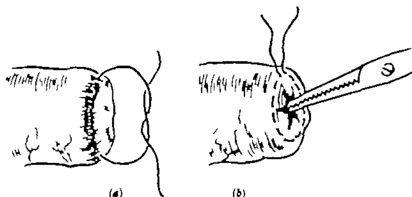


FIG. 57 Another method of closing an end of bowel (a) The Cushing suture is inserted as before and its ends are tied together (b) The puckered stump is buried with an invagination suture

it is wise always to reinforce a suture line with any fatty or omental tags that are available taking care not to strangulate their blood supply with the anchoring stitch If these do nothing else they will discourage the formation of adhesions and this is no small thing As a final safeguard in colonic cases a drain is never out of place but it should be placed some distance from the suture line and not right down to it otherwise leakage will be almost certain to occur

Paul Mikulicz Operation It is the persistent element of uncertainty in spite of all precautions and the fact that suturing occupies some little time and requires a fair degree

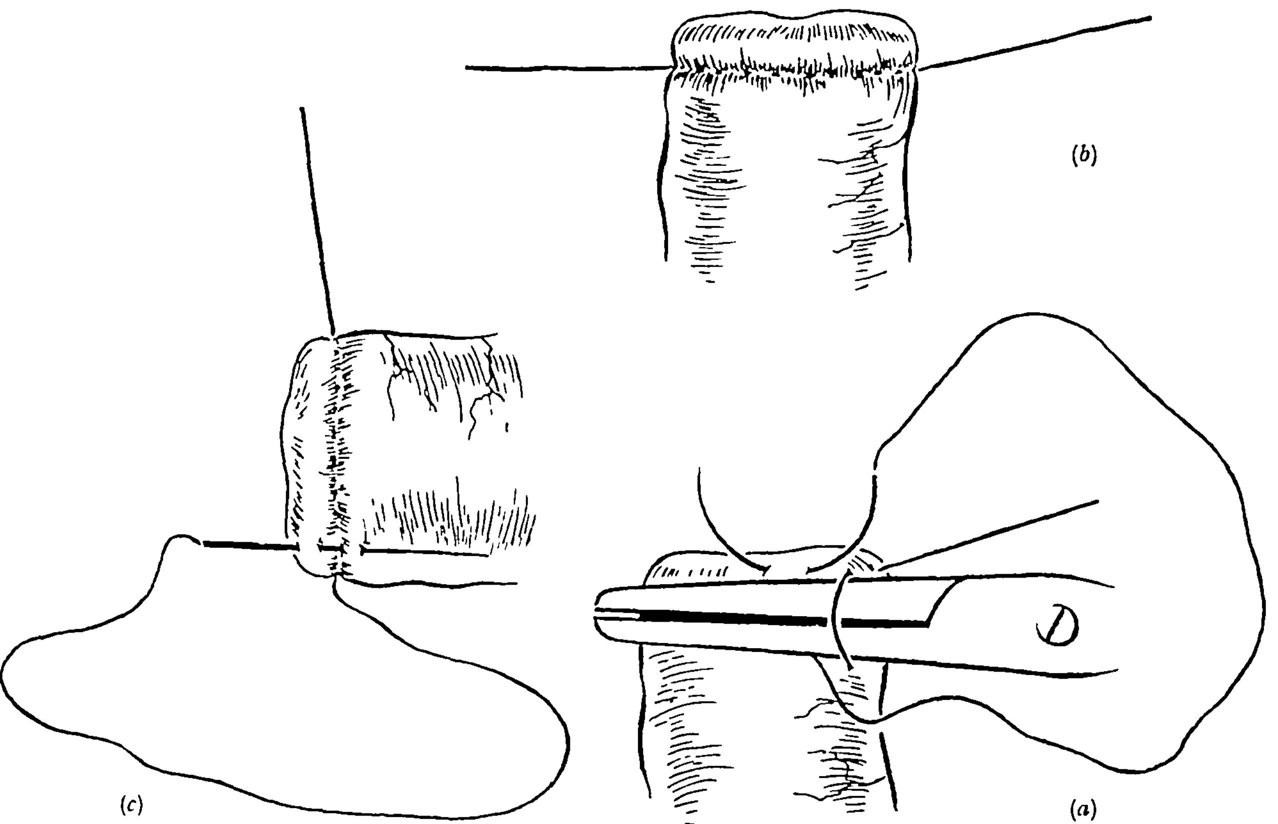


Fig 56 To close the end of a bowel (a) A continuous Cushing suture is inserted over a clamp (b) The clamp is removed and the Cushing suture drawn tight (c) The suture is continued as a Lembert

of skill that makes some surgeons timorous of intestinal anastomosis In the past various mechanical devices have been used to get round the difficulty Murphy introduced his button for the sake of speed the button was made in two halves which slipped into the bowel on either side and were then clipped together when the enclosed tissue sloughed the button was passed per *vias naturales* I have seen such a button hanging from an operating table by a piece of string—the anæsthetist employed it as a plumb line to gauge the tilt of the table after injecting a spinal anæsthetic—but I have never known one used by a surgeon

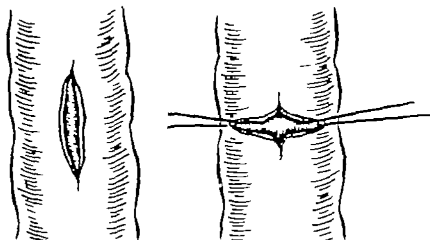


FIG 59 For enterotomy the bowel is incised longitudinally and sutured transversely so that healing will not cause narrowing

Other ways of avoiding suturing are still practised however Mikulicz (1850–1905) devised means not only of avoiding suturing but of avoiding the hazards of anastomosis altogether In his operation—

(1) the bowel is freely mobilised

(2) The mesenteric resection is carried out in the usual way

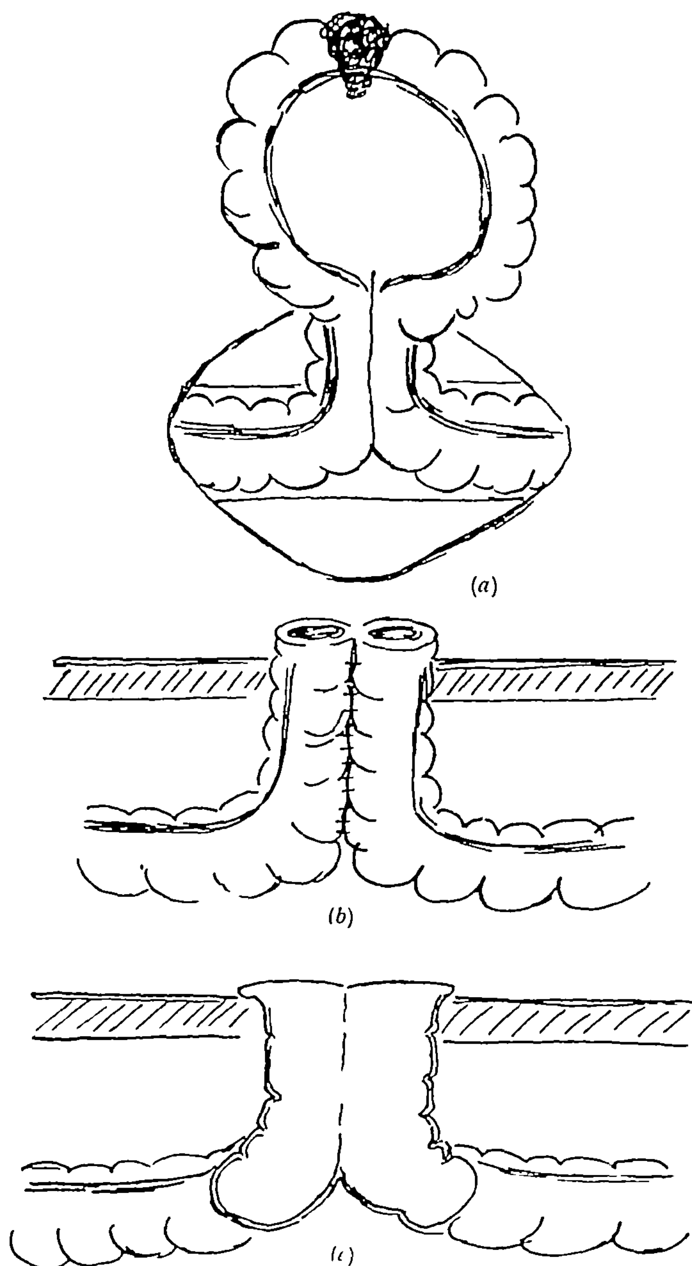


FIG. 58 A Paul Mikulicz resection (a) The bowel delivered and the antimesenteric borders united (b) The bowel resected (c) The spur is crushed

resolves We do not have the opportunity very often of inspecting a resolving peritonitis Perhaps if we did we might be surprised at the slowness of the process It is possible that many of our patients leave hospital clinically well but with loculated pus still lying about their peritoneal cavities

Since the issue is so unpredictable there is a very strong case to be made out for the avoidance of anything that might predispose to infection—even a mild and localised infection—during the course of an abdominal operation

But infection is not the only cause of adhesion formation Less dense but still undesirable adhesions result from the organisation of blood clot Every care should be taken therefore to see that the whole field is clean and dry at the finish of the operation And adhesions may form if a breach is left anywhere in the peritoneal cover especially in the visceral cover This is another matter that must be attended to before the abdomen is closed

One of the advantages of using a Lembert inverting stitch for an anastomosis is that the peritoneal surfaces are brought into close and uninterrupted apposition by it and they heal with a clean linear scar which shows small inclination to attract adhesions When the peritoneal coat is defective as in parts of the colon not only is healing more slow and uncertain but the muscle coat of the bowel and the adjacent extra peritoneal tissues tend to remain exposed at the end of the operation and later on may become adherent to loops of small intestine Some thing can be done to discourage this by covering the raw areas as far as possible with fat either omental or extra peritoneal it will serve as a mechanical barrier and although it may not remain entirely free its low vitality will prevent it from ever becoming densely adherent to anything

The Lembert principle is applicable also to closing the

(3) The proximal 4 or 5 in of liberated bowel are stitched together along their anti-mesenteric borders ,

(4) The distal loop so formed is brought out through a stab and the original incision is closed (Fig 58 (*a*)) ,

(5) Only then is the diseased portion removed by division between paired clamps (Fig 58 (*b*))

Ten days later the spur is crushed in the hope of establishing partial continuity during the two or three months before the colostomy is fit to be closed (Fig 58 (*c*)) The final closure of the colostomy is carried out extra-peritoneally, so that from beginning to end there is not the slightest opportunity of the peritoneum becoming infected from the intestinal contents

The fact that a long drawn out procedure of this kind was resurrected not so long ago from the surgery of the last century is strong evidence of the risks attending intestinal anastomosis But pre-operative chemotherapy has brought anastomosis into its own again Certainly there is much to be said in its favour The surgeon who masters its technique can adapt it to almost any requirement , and if he is clever with his needle need not be afraid of complications Only when dealing with a desperately ill patient will he need to resort to the method of Mickulicz

To Prevent Adhesions Forming The peritoneum is notoriously fickle One patient develops massive adhesions after an attack of peritonitis, another escapes them completely after a worse attack The reason for this is not easy to understand, but probably has to do with the way in which the infection

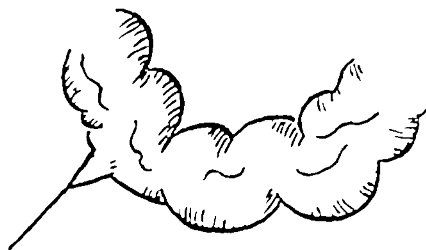


Fig 60 An adhesion may come out the intestinal wall , it should therefore be divided away from the intestine

CHAPTER VI

DUCTS AND FISTULÆ

To operate on a duct is a delicate business and one which is seldom undertaken voluntarily by anyone except an experienced surgeon. Lord Moynihan once remarked that a repair of the common bile duct often proves to be the supreme test of surgical skill Surgery has taken great strides since his day but it may be that his opinion is still defensible All this notwithstanding the novice is sometimes forced to deal with a duct which has found its way into the track of his knife and will not wait for reconstruction by more practised hands Even when postponement is possible it is seldom wise because delay usually means infection and infection is inevitably followed by fibrosis so that the difficulties and dangers of repair are increased a hundredfold

Such accidents strangely enough commonly occur not in the difficult but in the easy case The thin man not the fat is the victim. The reason for this is not clear It may be that the difficult operation is avoided by the less skilled surgeon it may be on the other hand that the easy operation is performed with less care and that the very accessibility of the parts renders them more vulnerable Much regret would be saved if every surgeon determined never to divide a structure until he has identified it beyond any doubt

The knife is not responsible for all duct injuries Sometimes the forceps is to blame—used in a hasty attempt to stop a hæmorrhage which obscures the field and threatens to exsanguinate the patient But such a hæmorrhage can

incision in the parietal peritoneum, reconstructing the pelvic floor, etc, but now the stitch is everting instead of inverting

Nowadays, however, it is not always possible to restore a complete peritoneal lining after the extensive ablations which are in vogue for the treatment of malignant disease The consequences do not appear to be so serious as might be expected, and some surgeons have come to attach less importance to *parietal* re-peritonealisation Certainly more latitude is permissible in the upper abdominal compartment, *i e*, above the colon, than the lower And it is often safer not to peritonealise at all than to reperitonealise partly, leaving a gap in which a loop of bowel may strangulate

The after-care of the patient contributes to the end result A speedy recovery from infection, under antibiotic therapy is more likely to be by resolution than by fibrosis It is a little questionable, however, whether Hilton's principle of rest to the inflamed part is not sometimes carried too far Prolonged suction with the Ryle's tube certainly keeps the bowel at rest, it may also give flimsy adhesions the opportunity to consolidate into obstructing bands, while the surgeon is lulled into a sense of false security by the absence of symptoms

escape of the dammed back contents when the duct is opened bearing in mind the likelihood that infection may be present Light clamps can be used on the ureter but they are not suited to the common bile duct and reliance must be placed on careful packing off and perhaps the skilful introduction of the nozzle of the sucker into the lumen when the incision is begun

The duct is now picked up by a couple of reasonably stout stay sutures one on either side of the proposed incision These should take a good solid bite of the whole thickness of the wall If they are not passed deep enough they may cut out altogether and even when this does not happen the indifferent grip introduces another disadvantage which will be seen immediately The two stays are held tautly up by an assistant while the incision is made between them This must always be longitudinal and should go boldly through all coats straight into the lumen endless time can be wasted and unnecessary damage caused to the walls of the duct if the incision stops short before the lumen is reached Fig 61 illustrates how badly placed stays may be responsible for this mistake The stone or stones should be removed as cleanly as possible a bruised mucosa being a potent contribution to stricture formation In fact the whole operation should be conducted so as to avoid any trauma that might damage structures which are exceptionally vulnerable The incision is closed with interrupted sutures of fine plain catgut which pick up the muscular

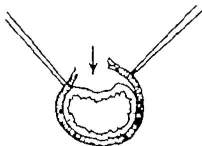


Fig 61 Exploring a duct. If the stays do not take a good grip a false lumen may be created by a partial division of the coats.

be much more effectively controlled by applying proximal pressure as described on page 54

This type of surgery is mainly called for in the biliary and urinary tracts, the circumstances of the two being widely different though certain characteristics are shared by both and, indeed, by other duct systems to which the surgeon as yet has not paid much attention

(1) All ducts are narrow The vas deferens and its tributaries are so narrow that most surgeons hesitate to interfere with them at all except, perhaps, to put them out of action Even the ureter and the common bile duct are narrow enough to make operation on them a matter of some delicacy It follows from this that one of the commonest forms of duct pathology is obstruction and one of the commonest complications of duct surgery is *stricture*

(2) Many ducts are provided with valves at their outlet to prevent regurgitation, and it must be confessed that the surgeon who transplants a duct from one place to another can do little to replace this mechanism The Coffey operation for transplanting the ureter into the sigmoid colon is an attempt in the right direction, but it is doubtful whether it is very effective

(3) The blood supply of a duct is usually exiguous and never super-abundant Consequently there is always a danger of sloughing if it is stripped too widely from its bed

The difficulty does not arise with the common bile duct because it is so short, here the problem is to get sufficient length to work with

Exploration of a Duct This is most often performed for the removal of a stone If there is any evidence of obstruction precautions must be taken against the sudden



FIG 63 A specimen showing the stump of a transplanted ureter protruding into the colon.

current fashion is to dispense with it There is no excess of common bile duct available for use in this way and when it is re implanted the surgeon must do the best he can to leave a larger lumen than usual with an end to-side anastomosis so that even if there is contraction the passage will still be adequate (Fig 64)

Anastomosis Anastomosis of a duct is not difficult if the ends can be approximated without tension and are of reasonable diameter and equal size Three stay sutures are inserted as guides and the union is effected with interrupted sutures of finest non-chromicised catgut which do not pierce the mucous membrane A continuous suture is not used because it might cause puckering A chromicised suture is anathema because it invites the deposition of salts and might become the nucleus of a stone if it resisted absorption for any length of time

coat only and are placed sufficiently close together to prevent any mucosal bulging The stays are not tied together to reinforce this layer because they are of too stout material and go too deep, they should be removed, but the neighbouring fat can be drawn over the incision as an additional protection A drain should always be left close by

Transplantation The common bile duct may be transplanted into stomach, duodenum, or small intestine, the ureter into the bladder, bowel or skin, and the urethra on to the skin

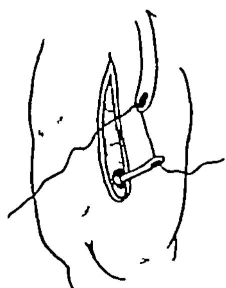


Fig 62 Invaginating the ureter into the sigmoid colon The other suture end is drawn through in the same way

Various methods of transplantation are in use, but none of them entirely avoids the risk of subsequent stricture Apart from guarding against any obvious narrowing at the time of operation it seems that the best way to prevent this complication is to make as neat a junction as possible with exact epithelial apposition The alternative is to leave a surplus of duct beyond the suture line when this is at all possible Fig 62 illustrates a technique for implanting the ureter into the sigmoid colon It will be noticed that when the stitch is drawn tight the ureter will be dragged well inside the bowel Care should be taken to avoid any tension, but slackness is equally undesirable When the anastomosis is complete the ureter should run as smoothly and comfortably to its new destination as it did to its old A comparable method can be used for re-implanting the ureter into the bladder and the principle can be applied to ureterostomy and urethrostomy by leaving a good-sized stump of ureter or urethra protruding through the incision in the skin The fate of this protrusion is, however, always a little uncertain, and the

role Vessels to a duct tend to run longitudinally The upper third of the ureter for instance usually depends on a slender branch descending from the renal artery Injury to this part may leave the distal end ischaemic and if it does no amount of expertise is likely to produce satisfactory healing But there is always a chance that the situation may be saved by adventitious arterial twigs joining laterally For this reason unnecessary mobilisation which might disrupt such twigs is to be avoided This principle applies in all duct surgery

Not uncommonly one end of the duct is much wider than the other the operation being carried out in the presence of some form of obstruction In such a case the narrower end can be cut on the slant or split up one side to increase its circumference (Fig 64)

Drainage Anyone who has seen the pus that oozes from the external urinary meatus after a catheter has been tied into the urethra for a few days will entertain no illusions about the disadvantages of the indwelling drain If it is used after a duct anastomosis or after such an operation as repair of a ruptured urethra it must certainly militate against sound healing On the other hand urine and bile are themselves irritating fluids and must also have an adverse effect on the processes of repair Some form of diversionary drainage gets over both difficulties Examples are nephrostomy for operations on

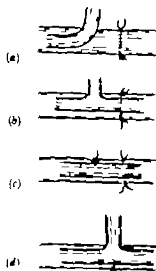


Fig 65 Drainage of a duct anastomosis (a) Proximal diversion drainage with an ordinary tube (b) Proximal drainage with a T tube (c) The drain perdu (d) Drainage *through* the anastomosis with any type of tube is most unfavourable

Even a plain suture is capable of leading to this complication if it invades the lumen of the duct and is exposed to the action of its contents When the definitive suturing is finished the surrounding tissues are drawn together with additional supporting stitches to take as much strain as possible off the anastomosis, tension of any kind being

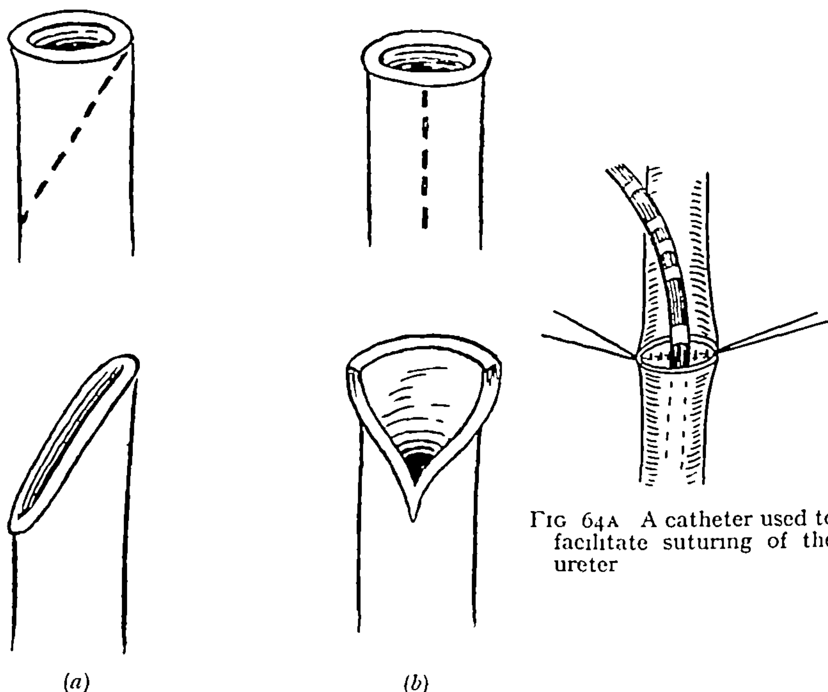


FIG 64 The end of a duct can be enlarged by (a) cutting it obliquely, (b) splitting one side and folding back the corners

FIG 64A A catheter used to facilitate suturing of the ureter

most undesirable There is no real reason why these anastomoses should not be as watertight as intestinal ones The suturing is delicate, it is true, but if fine instruments are used and something of the plastic surgeon's technique, the results ought to stand up to comparison Success or failure does not, however, depend entirely on the skill displayed Blood supply plays an important

a sphincter muscle The opportunities for mischief are obvious

It is easy to create a false passage at the lower end of the common bile duct In all probability the accident happens more often than is suspected but the practice of draining the duct after it has been opened gives the rent

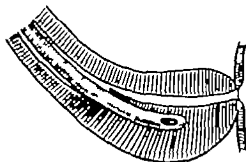


FIG 65A. A catheter goes astray in the bulb.

a chance to heal Otherwise consequences might be more serious Stricture of the duct has however been attributed to this cause

A false passage in the urethra is unhappily a common place It is not generally realised that such a passage leads directly into the blood stream (Fig 65c)

Case Note A soldier patient with stricture required regular dilatation Each time he went back to his unit after treat ment he reported sick. It was decided to admit him to hospital for twenty four hours to see what was happening After the next dilatation his temperature went up to 103 and B Coli was grown from the blood

Septicæmia complications are commoner than we think If we cross-questioned our stricture patients I have no doubt that quite a few of them would admit to having had a chill on the night after dilatation especially when the dilatation was followed by a little hæmorrhage

the ureter, and cystostomy or bulbar urethrostomy for operations on the urethra

Sometimes the two ends of a duct cannot be brought together in any sort of satisfactory fashion, and the use of an indwelling tube cannot be avoided If it is anchored to the cut ends of the duct at either end it will act as a scaffolding for the mucosa to grow along, but every effort should be made to secure mucosal continuity at least at one point

Case Note A deeply jaundiced patient was found to have a carcinoma of the common bile duct One inch and a half were resected, and the widely dilated upper end was united to the collapsed lower end by a few points of catgut over a rubber tube A drain was brought out through a stab and bile escaped for a fortnight After that recovery was rapid and complete

The French call a tube of this kind a " drain perdu," probably because it is seldom seen again It was used here because of the sketchy nature of the anastomosis X-ray later on showed that it has passed into the bowel (red rubber shows on an X-ray plate, unlike the amber and black varieties) In the biliary passages particularly, reparative power is often astonishing, as this case proves

Whether internal drainage is used or not, local drainage from the site of anastomosis or repair to the exterior is nearly always required as well, but this need not be by more than a sliver of rubber dam if the suturing has been carefully carried out

Passage of Bougies and Catheters along Ducts The Egyptians used a reed to relieve retention Since then every sort of instrument has been passed along the urethra, and latterly quite a variety, including a specially designed scissors, have been passed along the common bile duct

Now both these channels are delicately constructed and both undergo a change of direction before passing through

urethroscopy is another proof of the close association between the urethra and the circulatory system *Res ipsa loquitur*

Acute retention considerably increases the difficulties of catheterisation largely because of the circumstances in

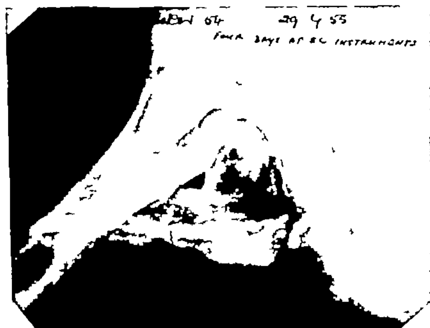


Fig 65c Urethrogram showing solution escaping into the blood stream An instrument had been passed three days earlier By courtesy of the *Post Graduate Medical Journal*

which the attack occurs Asepsis must often be imperfect the distressed state of the patient forbids any unnecessary delay while his fruitless efforts to relieve himself by squeezing out even a drop of urine only serve to increase the muscular spasm and render the passage of a catheter more difficult than ever

In spite of the urgency removal of the patient to hospital is still the best course When this is impossible he should be given an injection of morphine If it is given

Case Note Following clumsy attempts at catheterisation a patient ran a high temperature and staphylococci were recovered from the blood Subsequently a metastatic abscess developed in the arm

Case Note A patient collapsed during urethrography complaining of abdominal pain X-ray showed barium in the



Fig 65B A false passage in the bulbar urethra By courtesy of the *Post Graduate Medical Journal*

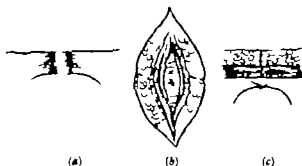
pelvic veins, which later reached the liver and spleen Nine years after, the spleen was still opaque Opportunities have arisen of demonstrating barium in the coronary and cerebral arteries under similar circumstances

The not unknown death from embolism during air

membrane and skin the track being lined either by granulation and scar tissue or by epithelium which has grown along it from either end

Of these fistulæ there is a great variety and each must be treated on its own merits Some indeed require no treatment at all They close either spontaneously or when a natural channel has been restored this happens with properly planned gastrostomies cæcostomies and cystostomies Others must be closed deliberately and this always applies to the ones that have become epithelialised

As with reconstructions in general the aim in these operations should be not only to close the fistula but to restore the normal anatomy of the part The original layers must



(a) (b) (c)
FIG 66. Closing a fistula (a) The fistula (b) The dissection (c) The suturing

be defined and isolated and the viscus freed from any abnormal attachments it may have acquired and restored to its former position Here is a description of how to deal with a recalcitrant cystostomy

A sufficient skin incision is made with the opening of the fistula in its centre The layers of the abdominal wall are carefully dissected out above and below where their relations are fairly easily recognisable Then the two dissections are joined to free the bladder so that it can be brought up to the surface The breach in its wall receives particular attention Any protruding mucous

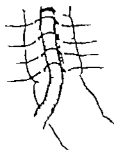
intravenously, relief is not long delayed, and there is now an opportunity for cleaning the parts, making what preparations are necessary to maintain asepsis, and injecting a local anæsthetic into the urethra

The choice of catheter is largely a personal matter Prostatic enlargement does not narrow the urethra—in its posterior part its capacity is actually increased—so there is no need to choose a small catheter One of the middle range which is not too rigid will be safest, the rigid variety is apt to go astray, and it is much more likely to do this in the anterior urethra than the posterior In nine cases out of ten the accident occurs in the bulb Here the channel widens, changes direction, and then closes down again, as it passes through the triangular ligament between the fibres of the compressor Some skill is needed in judging the exact amount of force required to overcome the resistance of this muscle Any force exerted in a wrong direction produces a false passage Progress is then halted, and when the catheter is withdrawn blood drips or flows from the meatus Not uncommonly the diagnosis is altered to one of stricture, and smaller and smaller catheters are tried without success If the truth is realised it may be possible by hugging the roof of the urethra to reach the bladder, but the cul-de-sac often defeats every effort to by-pass it and may remain open for weeks or months, or perhaps become a permanent feature in the anatomy of the part

It is because of this difficulty in the bulb and not because of the middle lobe that a Tieman's or a Coude catheter is so useful Once past the compressor the support of an assistant's finger per rectum just below the apex of the prostate, may prevent further accidents

To Close a Fistula The word fistula is employed here in its true sense of an abnormal communication between mucous membrane and mucous membrane, or mucous

and close up rapidly when it is taken out With these operations it is important that the tube should be snugly and securely fixed to the small incision in the viscus and that the viscus itself should be anchored to the abdominal wall A cystostomy tube also must fit snugly into the bladder and travel from there to the skin as obliquely as may be The low cystostomy with a tube coming out just above the pubis shows a great tendency to leak and seldom heals of its own accord


Fig 69 An enterostomy before the sutures have been drawn tight

membrane should be carefully trimmed away and the surrounding scar tissues completely excised exposing healthy musculature which can be sutured with good hope that it will heal quickly and firmly If this suture line is of any length it should run at right angles to the abdominal incision This is the most important part of the operation, because if there is any leakage at this level the fistula is bound to reform no matter how much care is devoted to the remainder of the repair Once the bladder is securely closed it is allowed to drop back into the depths as far away from the pubis as possible, and the now clearly defined layers overlying it are brought together *secundem artem*, usually with provision for draïnage in case the worst happens and leakage occurs in spite of all precautions against it *Mutatis mutandis* this technique will be found to cover most operations of the kind With bowel fistulæ the principle of inversion should be honoured Some of these can be closed without opening the peritoneum, so avoiding the risk of soiling or perhaps starting a peritonitis

The Surgical Fistula The techniques for gastrostomy, jejunostomy, cæcostomy are fairly well standardised and

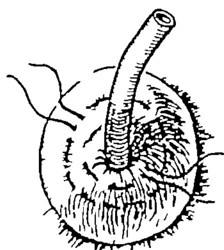


Fig 67 An invagination or inkwell cæcostomy

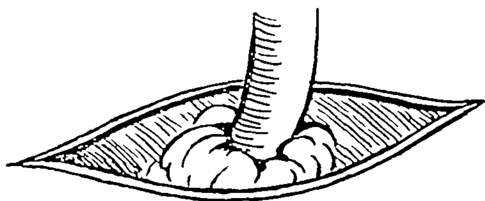


Fig 68 An inkwell cæcostomy does not leak and closes immediately the tube is removed because peritonealised surfaces come into intimate contact

accepted Diagrams illustrate alternative methods The idea of creating some kind of valve to prevent leakage is common to both So is the long, peritonealised channel which will embrace the tube closely while it is in position

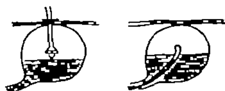


FIG. 70. Bad bladder drainage.

and the prospect of an obstruction later on His drain acted as a bung and a foreign body

Case Note A catheter stopped draining three days after a closed prostatectomy The efforts of the bladder to empty itself provoked hæmorrhage and clots accumulated rapidly The patient went into a state of bladder shock.

Here the catheter not only failed to drain but also obstructed the via naturalis which might have functioned quite well at this stage

Some Suggestions (1) A drain if it is to do its work must be adequate in size and situation having regard to the position which the patient will occupy in bed. Dependent drainage where possible and down to the depths in the abdomen are good rules The latter of course provides against deep pocketing

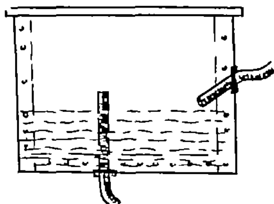


FIG. 71 These pipes will not empty the tank and tubes similarly placed will not drain an abscess.

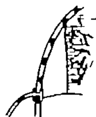


FIG. 72 Pleural drainage by a Tudor Edwards tube. As the diaphragm rises drainage will cease The tube should be sited higher

CHAPTER VII

DRAINS

A GREAT many drains never drain There may be no harm in this A drain may have been left as a safeguard against leakage which never occurs (*e g*, after an anastomosis of large bowel), or to delay healing at one end of a wound so that pus, which may not form for a week or two, will have a chance to escape It is in this type of case that the wound is reported to be " beautifully clean " on the second day after operation Of course it is, but what will it be like when the stitches are taken out? If, by then, the superficial layers are healed solidly from end to end any deep accumulation is likely to spread far and wide before it reaches the surface

But there are times when exudate is plentiful from the start, and yet nothing comes away through the drainage tube

Case Note An abdomen containing a lot of free pus was drained by a tube passing through a suprapubic stab into the pouch of Douglas There was no discharge until the tube was removed two days later, when pus poured out in great quantities

Probably if this tube had been shortened or rotated to free it from coils of gut or plugs of omentum it would have drained quite well It is true that drainage from the pelvis is uphill, but it should not be forgotten that there is a considerable positive pressure within the abdomen, witness the readiness with which blood, etc, comes to the surface during an operation instead of spreading around the peritoneal cavity In this instance the patient probably went home with dense pelvic adhesion

is only too anxious to insinuate itself into any peritoneal gap that may remain after the removal of a tube and this protrusion will certainly leave the patient with a ventral hernia if it does not establish a sufficient breach to produce wound dehiscence It is the peritoneal stitches which count in these cases But even when properly placed their proximity to the tube renders them liable to early absorption For this reason they should be interrupted Then their disappearance will do no more than local damage

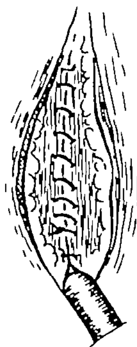


Fig 74 An interrupted stitch is placed next to the drain if it is prematurely absorbed the main suture will not be affected

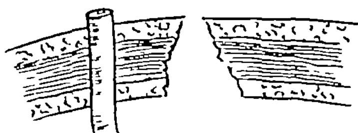
The same care should be taken with a tube left in a hollow viscus or duct With gastrostomy cæcostomy or choledochostomy the fit must be exact Otherwise leakage is inevitable

(6) When bleeding is concerned an opportune ligature is worth any amount of drainage Blood clots quickly and once clotted it will never drain Besides cut vessels often retract and may produce an extravasation in tissue which does not communicate with the area drained. After a radical operation for hydrocele it is customary to drain the scrotum but the largest tube will often fail to prevent the formation of a hæmatoma The loose cellular tissue of the part acts like a plug of cotton wool and effectually blocks the exit This may occur too after many amputations

When the worst happens and a hæmatoma develops in these cases the best thing to do is to take the patient

(2) *A drain should be as short as possible, and as straight as possible* For example, the pelvis should never be drained through a grid-iron incision The Tudor Edwards drain for the pleura fulfils both requirements to perfection when it is properly placed

(3) It is better to drain through a separate stab than through the wound of approach If this is impossible, the drain should be placed near the lower end of the wound so that infected material has less opportunity to seep between its layers When a stab is used it may be safer to leave a small drain in the fatty tissue of the main wound instead of closing it completely, fat is peculiarly vulnerable to infection



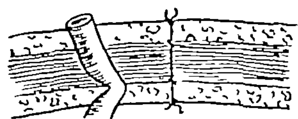


FIG 73 If a drain is inserted into the peritoneal cavity through a stab without allowing for the drag when the main wound is closed the tube may be obstructed

(4) Narrowing or kinking must be guarded against Close suturing may cause either So may " drag " Take as an illustration drainage through a stab after a cholecystectomy If the stab is made in the flank and the drain is inserted without allowing for the retraction of the parietal peritoneum, then, when this is pulled taut by stitching up the wound the tube will be angulated This can be avoided by pulling the peritoneal layer into position before making the stab For a similar reason a tube should never be passed through a paramedian incision If it is, the rectus muscle will tend to kink it while it is in position and close the track after it has been removed Since discharge never dries up immediately, leaving an adequate track is very important

(5) Suturing round a drain should be snug without encroaching on it in any way In the abdomen omentum

to put things right. All the more reason for fixing the tube securely in the first place.

(10) A short tube should always be transfixed by a safety pin as well as by a stitch A stitch alone may cut through and allow the tube to disappear into the depths For a long tube a snugly encircling stitch is often all that is needed All tubes should be watched and adjusted when necessary (see case note above) Unfortunately this means disturbing the dressing and affords a fresh opportunity for introducing infection

(11) It is seldom right to say take this tube out on such and such a day Everything depends on how much it drains Where hæmorrhage is concerned it is usually safe to reckon that oozing will have stopped at the end of forty-eight hours though this is not always so A tube left in the pouch of Douglas when there is free pus in the peritoneum may be removed at the end of forty-eight hours with advantage after that it will probably become shut off and only serve to stimulate the laying down of adhesions But a tube in an abscess cavity must be left much longer perhaps a fortnight or more Empyema drainage is not complete until the pleural space is obliterated as shown by X ray after the injection of lipiodol. The same principle applies to the drainage of any other accumulation enclosed between rigid walls

Total Drainage. Tube drainage must often be imperfect The orthopædic surgeons are so dissatisfied with it that they have almost given it up After toilet of a compound fracture or an operation for ostetomyelitis the wound is left wide open and only lightly packed with vaseline gauze How could drainage be more complete? Vaseline gauze is preferable to dry because the latter soon becomes sodden and entangled in granulations so that discharge has difficulty in making its way to the surface The vaseline gauze never becomes adherent adapts itself to

back to the theatre and evacuate it with full aseptic ritual Otherwise convalescence will certainly be delayed and may be complicated by infection

(7) The pressure of a tube is bound to cause some degree of necrosis if it remains in for any length of time Erosion of vessels, sloughing of tendons, breaking down of anastomoses, may result from this It follows that no tube should be allowed to remain in immediate contact with such vulnerable structures Nearly always tissue

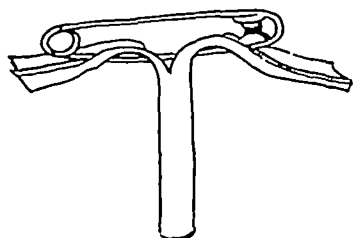


FIG 75 An improvised flange on a drainage tube to lie against the surface and maintain correct length

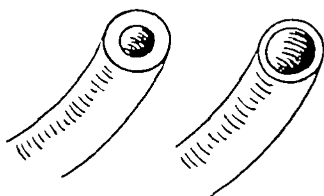


FIG 76 Two drains of equal outside diameter may have very different lumina

can be interposed or some interval left between the two And the tube used should be soft, or its place taken by a piece of rubber dam

(8) To have to drain is always unfortunate because the drain leaves a breach in the defences of the body against infection The danger is greatest when the urinary or biliary tracts are being drained, but it can never be entirely absent when the surface of the body is thrown into direct communication with the interior Closed drainage is imperative for urine or bile

(9) A drain from a viscus to the surface establishes a track for itself in about ten days Should it slip out sooner than this there is a danger of extravasation unless it is replaced without delay This can hardly be done blindly, and probably another operation will be required

Case Note The catheter was removed on the fourth day after a retro-pubic prostatectomy streptomycin being used prophylactically At no time was there any clouding of the urine or stickiness of the meatus but the patient complained of a general tenseness of the glands and shaft of the penis He returned soon after discharge from hospital with a pronounced narrowing of the whole urethra

The urethra is not the only part that is vulnerable Since the prostatic ducts drain into it and the ejaculatory ducts put it into direct communication with the seminal vesicles and epididymis all these may suffer consequentially

Although infection must be accepted when an indwelling catheter is used much may be done to minimise its severity and avoid its sequelæ

1 Manufacturers have only recently interested themselves in the important question of the reactions that take place between human tissues and materials brought into contact with them and there is still much work to be done before these problems are settled but there can be no question that the types of catheter put on the market during the last few years are much superior to the old ones An indwelling catheter should be constructed of a smooth and durable substance which does not crack or corrode it should be flexible so as to accommodate itself to the curves of the urethra and it should be as thin walled as possible in order to give the maximum inside diameter with the minimum outside Also it should be boilable

Plastic can lay claim to most of these advantages gum elastic to none of them Latex seems to be better tolerated by the urethra than ordinary rubber

Of recent years the Foley catheter has enjoyed great popularity because of its comfort and cleanliness although for anatomical reasons it does not drain as well before prostatectomy as after The balloon should be tested for emptying as well as filling before using it Contretemps

the diminishing depth of the healing wound, and is eventually extruded completely without leaving any threads behind to act as foreign bodies It is interesting to notice that even this drastic method of drainage was not always successful with war casualties In through-and-through gunshot wounds of the femur pus tended to track along the hamstrings into the buttock when the limb was elevated on a splint *because the drainage was no longer dependent*

Proctologists observe the same principle of total drainage An ischio-rectal abscess is dealt with nowadays by making a wide cruciate incision in the skin which forms its base, and cutting away the flaps so formed, so that the abscess is left without a floor Even the abdominal surgeon has occasionally taken a chance and left all but the deep layer of his wound open in a septic case, to be agreeably surprised by the soundness of the healing and the absence of any hernial weakness afterwards (this suggests that the deep suture is the most important one, if it holds nothing can protrude to keep the other layers apart) The risk of hernia would be still less, of course, if secondary suturing were carried out when it became clear that infection was either not going to be a serious menace or, having developed, was responding rapidly to treatment

The Indwelling Catheter Perhaps the indwelling catheter is the most commonly used drain of all In many ways it is also the most dangerous, so it may not be out of place to speak of it here at some length

When the antibiotics were first introduced it was hoped that catheter urethritis would become a thing of the past, but this has not happened The continuing irritation of the catheter chafing against the mucous membrane still produces a continuing infection Sometimes it almost seems as if antibiotics do more harm than good

rules can be laid down but the size of the penis can be taken as a rough guide to the size of the urethra and the feel of the catheter as it is introduced should confirm that it is a comfortable fit An 18F is nearly always safe a size smaller than this may be sufficient to drain urine but will not allow the escape of clots after operation

3 The external meatus deserves particular attention since it is the narrowest part of the canal and not unlikely to become the seat of stricture Even a well chosen catheter may be held up here during insertion if it has not been generously lubricated When this detail has been attended to and there is still a suggestion of tightness a little novocaine should be injected and the meatus slit well back to one side of the frænum. Not only does this get over the immediate difficulty but it ensures drainage later on.

4 When a catheter is to remain in the urethra it is more than ever important that no loophole should be created at the time of its introduction for the escape of infected material into the corpus spongiosum where even if it did no more serious mischief it might lead to peri urethral infiltration with subsequent fibrosis it is the spongy tissue surrounding the anterior urethra that renders it so much more prone to stricture formation than the posterior *En passant* one wonders how many of the multiple strictures still seen in our clinics are due to the instrumentation and not to the original infection

5 With the catheter safely in position the question arises of how it is to be fixed if it is not self retaining When strapping is used it must not be allowed to constrict the penis or all the care taken over the fit may be wasted. Tight strapping here has been known not only to compress the urethra but to lead to actual sloughing of its floor A catheter should always be connected up to a jar at the side of the bed by a length of tubing If its end is allowed

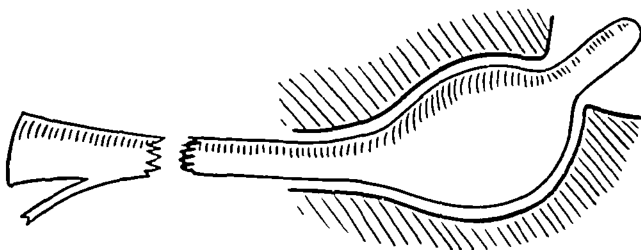


FIG 76A A Foley catheter is correctly sited when the inlet tube is below

have been recorded Over distension is unnecessary and may be dangerous , 10 mls of fluid is enough to keep the catheter in position , further stretching of the prostatic bed may lead to necrosis of the rectum Care is needed also to see that orientation is correct, with the balloon and its inlet tube lying posteriorly otherwise the tip may become kinked

The Foley is hollow tipped, which enables an introducer to be used with it when required And it has two lateral holes, so that if one lies against the mucous membrane of the bladder the other is free The inlet tube notably diminishes the lumen of this catheter

2 Whatever catheter is chosen should be loosely fitting so that discharge can escape freely alongside it Nothing

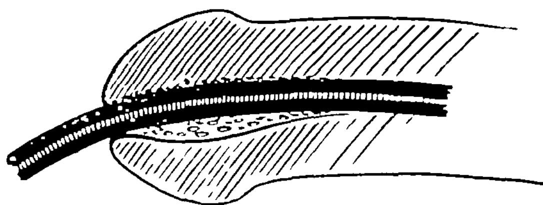


FIG 76B A catheter which is tightly gripped at the meatus dams back secretion

is so likely to provoke stricture formation as a tight fit with damming back of secretion , this is much more important than the length of time the catheter is kept in Measurement has shown that the anterior urethra may be twice as wide in one man as another, so no hard and fast

CHAPTER VIII

CLOSING THE WOUND

The Status Quo Ante It has been said that the good surgeon may be recognised not by the way he cuts but by the way he sews up The two processes are so closely related that it seems arbitrary to separate them in this

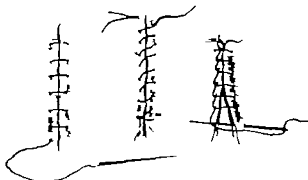


Fig 77 Two types of continuous stitching and a blanket stitch

fashion but perhaps Mikulicz meant to suggest that an operation could be regarded as having a destructive phase followed by a reparative Looked at in this light there can be no doubt about the importance of the reparative phase

Sewing certainly seems to excite less interest than cutting The cutting is done at the start of an operation and the sewing at the finish and there may be a temptation to relax a little once the main objective is achieved Whatever the reason instances of neglect are not difficult to find—the coverings of the spermatic cord left gaping after excision of a hernial sac so that the contents escape and become adherent to the surrounding structures or

to lie in a bottle placed between the patient's thighs, its contents may be sucked back into the bladder when the bottle fills

6 It is the house surgeon's duty on his twice daily visit to see that this whole area is kept scrupulously clean, and particularly that the meatus does not get gummed up by discharge A patient with an indwelling catheter is apt to develop an insidious paraphimosis, which adds to his discomforts without causing actual pain It may escape notice and become difficult to correct if the routine of inspection breaks down

7 Finally, catheter drainage should be discontinued at the earliest possible moment If it seems likely that it will be needed for more than a few days it is better eschewed altogether and supra-pubic drainage used from the start if it has been started and some form of drainage must be continued then the switch over from one to the other must not be delayed Failing this an early vasectomy under local anæsthesia may save a lot of trouble

suturing presents no difficulty—the anterior and posterior rectus sheaths are capable of taking any reasonable strain With muscle-cutting incisions however whether in the abdomen or elsewhere sheaths are not so ready to hand In the loin for example they tend to disappear where the lumbar aponeurosis splits up Nevertheless an attempt should always be made to find a fascial bite for the needle Without it there can be little safety Muscle suture can only be counted on to obliterate dead space if it is pulled tight the tissue embraced by it necroses and as has been said if it is subjected to any strain it cuts out

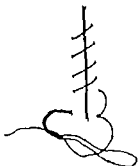


FIG. 79. Reversing the last stitch to give a better knot.

There is another reason for suturing a muscle sheath—it prevents the muscle from becoming adherent to its neighbours Haphazard suturing in the loin may result in the three flat muscles becoming bound together and since each of them acts in a different direction this is certain to interfere with function and cause post-operative discomfort The effect of muscle tether is seen very clearly when skin becomes adherent to the external oblique over an appendicectomy incision that has been infected —every time the external oblique contracts the skin is dragged upon The same thing must happen quite commonly

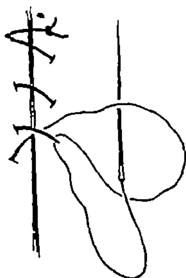


FIG 80 A method of interrupting a continuous suture with a knot for greater security

the renal pelvis left open after a pyelotomy so that it is a week or more before the dressings are dry of urine

To restore the parts to normal as far as possible is not a bad objective for the closing stages of an operation It is not unusual, for instance, when closing an incision in the abdomen to take the peritoneum and the posterior sheath in the one running suture with the result that extra-peritoneal fat intervenes between the edges of the sheath all along the wound and sound healing is effectually prevented The normal relations are not restored, and a hernia may develop in consequence "Like to like and nothing in between" is a sound motto to have in mind when stitching up Leaving anything to nature to put right is a mistake, for nature, though a good doctor, is a poor surgeon

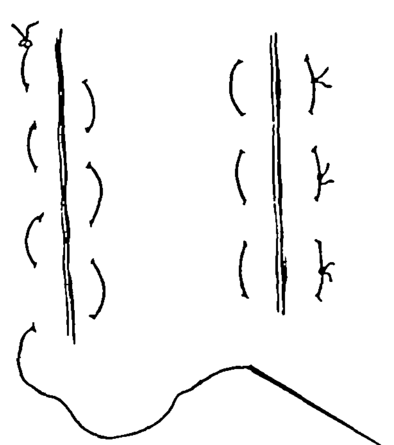


FIG 78 A continuous mattress or glover stitch and an interrupted mattress stitch

Tensile Strength of a Wound The strength of suturing lies in the fascial and aponeurotic layers Rectus sheath will stand up to a 3-lb pull, while 1 lb will drag a suture out of muscle or fat Neither of these latter, therefore, can play any significant part in holding a wound together, and it is unreasonable to use materials for uniting them with a much greater tensile strength than they possess themselves—it will merely cause irritation without adding anything to security No 00 catgut has a breaking strain of 3 lb, so No 0 used on a sheath gives a good margin of security and No 1 allows for all vagaries of manufacture No 000 is strong enough for muscle or fat

With an incision like the paramedian in the abdomen



FIG. 82. Epigastric hernia after a laparotomy incision a suture line must have given way This proved a greater disability than the original one.

the parts in apposition until the suturing is complete In either case the aim is to avoid strain until the load is spread. Pull on any individual suture is then reduced to a minimum Working along these lines the Lilliputians trussed up the sleeping Gulliver so effectively that he could not stir hand or foot when he woke.

But the danger of cutting out is not past when all the mechanical difficulties have been allowed for If a suture



FIG 83 A small omental protrusion through a gap in a suture line may form a wedge which leads to disruption of the whole wound.



FIG 84. Once a wound is closed the sutures are more likely to cut out than untie.

in the deeper planes although it is not obvious to the eye

Continuous or Interrupted There is much to be said against continuous suturing It puckers the wound It strangulates its edges It allows no room for discharges to escape If any part of it, or the knot which secures it, gives way the whole suture gives way Each interrupted suture, on the other hand, is an independent unit, relying for survival on nothing but itself And the gaps between adjacent sutures give blood, serum or pus a chance of making a way to the surface

Interrupted sutures should therefore be the choice when infection threatens But the continuous suture proves satisfactory in the clean case It is quicker to insert and gives a neater finish than the other, and if every fourth or fifth loop is locked no great harm can come from the puckering or strangulation

Breaking and Cutting Out of Sutures. A suture may break or cut out while it is being inserted With a continuous suture this can usually be prevented by leaving the loops slack until several are in position, and drawing the whole lot together With interrupted sutures it may be necessary to rely on temporary tension stitches to keep



Fig 81 Tugging on a suture line may convert the knot into a slip which will give way later on The catgut should not be drawn tight until 2 or 3 loops have been inserted

extra care should be taken to obliterate all dead space because they undoubtedly have the effect of keeping the lax subcutaneous tissues together (Fig 86)

Healing of Aponeurosis Although there is so much to be said against the use of tension sutures it must still be admitted that entire reliance cannot be placed on catgut because of the risk of its early dissolution Plain catgut may be absorbed in a few days and no one uses it for serious suturing But even the chromicised variety may disappear long before the advertised ten twenty or thirty-day period Cases are not unknown in which either from inefficient processing or some peculiarity of the patient s tissues it dissolves overnight

Such catastrophes are quite exceptional but there is another and more constant factor to be reckoned with This derives from the fact that aponeurosis is one of the least vascular tissues in the body and in consequence heals extremely slowly

Exact measurement of the rate is not possible in man but in the rabbit it appears that tensile strength does not begin to develop until the sixth day thereafter it increases fairly rapidly until the second month but subsequent progress is slow and not complete until a year has elapsed By way of contrast the skin is fully healed on the twenty first day at a time when aponeurosis has still four fifths of its journey to go [1]

If these observations have any bearing on what happens in the human subject they throw grave doubt on the reliability of catgut even when it lasts the full twenty or thirty days

It is worth noting that fibrotic aponeurosis *i e* aponeurosis at the site of an old incision being still less vascular takes even longer to heal. The surgeon who sutures such tissue may congratulate himself on its

[1] 195 Douglas D M *B J S* 40 79–84

is drawn too tight even aponeurotic tissue will undergo necrosis, a process greatly accelerated by any infective complications that develop in the wound These are the cases in which nurse finds a loop of catgut with the knot still firmly tied amongst the discharges on the dressing Tight suturing therefore defeats its own ends Apposition of the cut edges is all that is required

Deep-tension Stitches These are seldom employed except in abdominal wounds Even so they are open to several objections —

(1) The needle may sever the peritoneal suture if it is passed blindly after stitching the anterior rectus sheath

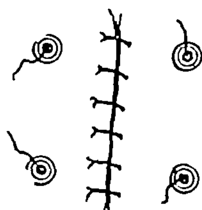


Fig 85 Buttons nipped on to tension sutures instead of tying them

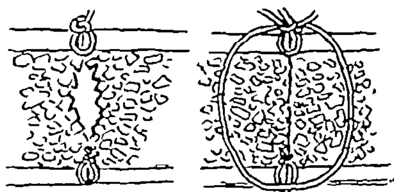


Fig 86 An all coats stitch as well as relieving tension helps to obliterate dead space

And no matter what care is taken it often lacerates a blood vessel and leaves a hæmatoma in its track

(2) The stitch holes put the depths of the wound into direct communication with the skin and are very likely to become infected

(3) The stitches are liable to leave permanent cross hatchings, and may cut out altogether in local œdema or abdominal distension develop during convalescence Tubing threaded on each suture (it should be full length to serve its purpose), or buttons with lateral fixation (Fig 85), are safeguards against these risks

(4) Most wounds heal just as well without this kind of reinforcement If tension sutures are omitted, however,

prophylactic they should be tied with due care to avoid including omentum or even a loop of bowel Alternatively the anterior rectus sheath itself may be stitched with the wire taking alternate deep and narrow bites of the aponeurosis or the ordinary catgut suture in the anterior sheath can be supported by the stitch illustrated in Fig 88A This stitch gives gentle but secure approximation and has proved its worth on many occasions

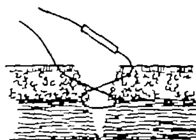


FIG 88A. A useful figure of eight tension stitch.

Wound Disruption Many factors contribute to this complication—poor suturing (perhaps from insufficient relaxation) post-operative strain from coughing vomiting or ileus protein starvation either from pre-operative causes such as carcinoma of the stomach or post-operative from over much reliance on intravenous therapy and sepsis Early ambulation does not play a part and it is as well to confess that some cases admit of no explanation at all No incision is immune from this accident but fat people with gall bladder disease are peculiarly prone to it and in acute pancreatitis it is almost to be expected

Case Note Bronchoscopy at the end of an operation for the purpose of clearing the lungs of secretion led to violent retching Bulging of the wound was noticed and when it was re-opened all the silk sutures in the anterior rectus sheath were found to be broken.

Bronchoscopy is not a usual addition to an abdominal operation but it is not infrequently necessary to pass a Ryle s tube and this may cause quite a lot of retching and vomiting

Before disruption manifests itself (this is usually

holding powers, but he should not overlook the accompanying drawback

The case for routine reinforcing of catgut with interrupted non-absorbables, especially in the posterior sheath, which is the more important of the two, is therefore a strong one When this is done in the anterior sheath the sutures should be inserted so that the knots lie deep, otherwise their cut ends may scratch the under surface of the skin and cause discomfort later on

Some surgeons, especially those who like to see their patients out of bed on the second or third day after operation, make a practice of using non-absorbable sutures in nearly every case, whether there is a likelihood



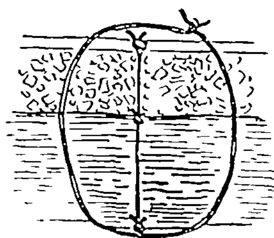


FIG 87 An all layers steel wire tension suture

FIG 88 A near and far stainless steel wire tension suture, it should *not* be drawn tight

of disruption or not They believe that wire or nylon cause less trouble than catgut even if the wound does become infected They do not make the same claim for silk, of course

When it seems necessary to take *special* precautions against disruption it is doubtful whether a few additional tension sutures are sufficient Three or four stainless steel wire sutures carried through *ALL* layers are a sound

But the catgut cannot always be blamed in these cases Occasionally it will be found to have cut out from end to end without any interruption in its continuity The surgeon must then ask himself whether he is not responsible for what has happened Surely too much tension has resulted in necrosis of tissue all along the wound

Once the resuturing of a disrupted wound is complete there is every chance that it will heal quickly and well because fibroblasts are already present and there is no time lag before they go into action Nevertheless every care should be taken to see that pull is reduced to a minimum For this purpose there is no better device than a corset

Ventral Hernia Complete disruption is seen only in about 1 per cent of cases but partial disruption probably occurs much more commonly remaining unrecognised until a hernia develops later It is now believed that many such hernia start soon after the operation perhaps before the patient leaves the theatre The case note on page 119 records such a mishap Violent uncoordinated muscular contraction in a semi-conscious patient is likely to do much more harm than ordinary coughing or movement

Case Note At the end of a fascial repair of hernia the patient began to retch A tearing noise was heard—the strain had torn a strip out of Poupart s ligament and the repair was ruined

Case Note A low herniorrhaphy was performed in a child the sac being divided before the ligature on it was cut As the stump receded into the inguinal canal the child coughed and omentum appeared in the wound The momentary tension on the ligature after division of the sac had pulled it away In this case the cough was a happy accident

One might expect the hernia itself to throw further light on the problem and very often it does although the findings may be affected by the type of incision used and

between the eighth and tenth days) there is often a discharge of slightly blood-stained serous fluid from the wound If the nurse in charge is alert to the significance of this development she may be able to get surgical aid before eventration, with its attendant shock, adds to the difficulties of treatment

Depending on the extent of the disruption it may only be necessary to do a limited repair, or complete re-suture may be required In the latter event the services of a skilled anæsthetist are essential this is not the occasion when a " little local " or a " whiff of gas " is sufficient

If it is possible to repeat the original suturing in layers so much the better, but quite frequently closely spaced interrupted sutures of non-absorbable material through all layers, including skin, will be found more serviceable, because of the difficulty of picking up the layers one by one There are rare cases, mostly associated with sepsis, in which even a through-and-through suture will not hold In such desperate circumstances the gap may be covered by a piece of tulle gras anchored to its margins in the hope that granulations will form underneath and eventually become epithelialised I have seen this trick succeed beyond all expectations in an abdominal wall defect produced by high explosive

Whatever the extent of the disruption, the surgeon who is called upon to deal with it should make a point of noting, and perhaps putting down on paper, what has happened to the catgut sutures There is still a lot to be learnt about their behaviour in the tissues, and the chance of observing their appearance in the wound at this early stage does not arise so often that one can afford to let it slip By studying their eccentricities we may one day be able to give the manufacturers information which will enable them to produce a more consistently reliable material

The former is discussed in another chapter The latter should aim at *careful bringing together of the subcutaneous fat fascia etc with the finest absorbable sutures followed by full thickness approximation of the skin from end to end of the wound*

The ease with which sutures pull out of fat has already been mentioned. Fat not only refuses to hold sutures but actively resents their presence It will not tolerate catgut in any of its bulkier or more irritant forms The

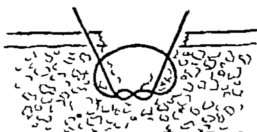


FIG 89 Fat can usually be approximated by suturing the deep fascia, when the fat itself is sutured the knot should be deeply A round bodied needle is less likely to pierce a blood vessel and cause a hæmatoma.

sutures used should therefore be of the finest and confined as much as possible to the fascial layers (Fig 89) This does not mean that anything short of complete coaptation is sufficient To leave a dead space invites infection and may eventually lead to an ugly adherent scar

If the scar is to be really hair line the skin stitches also should be of fine calibre and preferably mounted on atraumatic needles There is a wide range of materials to choose from and most of these will prove satisfactory if they are impermeable so as to offer no lodgment to micro-organisms and coloured so that they do not escape the attention of the nurse who removes stitches Catgut should never be used in the skin if it is its irritant effect plus the infection lurking in the depths of the sweat and sebaceous glands will almost certainly cause trouble

A stitch whether irritant or not may easily carry

the number of layers that have given way With a vertical incision in which both layers have *stretched*, one would expect the herniation to extend over the entire length of the wound Quite frequently this is not so Although the hernia may have mushroomed in all directions, the actual gap through which its contents protrude may be quite localised Moreover, the edges of the gap are thickened and not attenuated, as they would be if the scar had gradually weakened

If it is agreed that ventral hernia commences during the post-operative period, then the sooner it is repaired the better, before shortening of the oblique muscles puts all hope of approximating its edges out of the question For an oblique muscle released from its insertion will shorten as certainly as a flexor in the forearm Unfortunately diagnosis of what is happening in these early days is difficult or impossible It is only in disruption that the situation declares itself unmistakably When it does so prompt resuturing should only be postponed if the patient's general condition absolutely forbids it

Stitching the Skin However successful an operation may be, the patient and her friends are inclined to base their estimate of it on the appearance of the scar No doubt there are times when the surgeon must ignore this bias and make good exposure his principal objective, but whenever possible he should respect it, because it is not nearly as unreasonable as it sounds If the cosmetic result is to be satisfactory two factors must be considered —

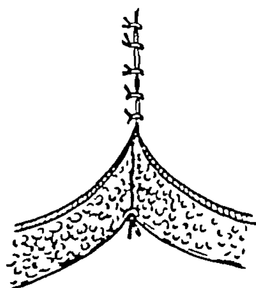


Fig 88b Fat held together by a suture in the deep fascia

(*a*) The planning of the incision
(*b*) The technique of stitching



FIG 93. Inserting all stitches together cutting the lot.

infection from these glands into the subcutaneous fat if it is allowed to penetrate so far This is one of the objections to tension stitches, which, of course, are quite out of place in any work that aims at cosmetic values But

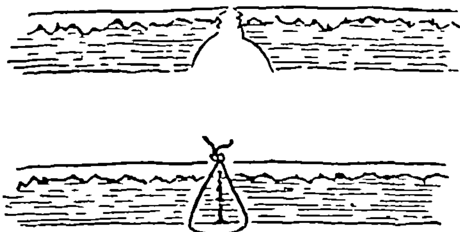


FIG 90 A skin stitch that leaves no mark

even an ordinary skin stitch may start mischief if it includes anything beyond the dermis in its embrace

Because of its elastic content, the dermal layer of the skin shows an inveterate tendency to retract and invert

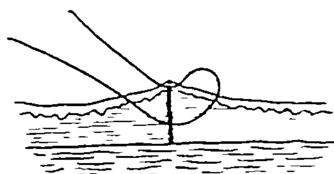


FIG 91 A right-angled mattress stitch

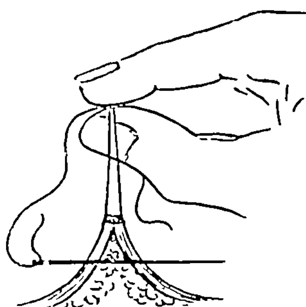


FIG 92 To get accurate apposition insert the near half of a mattress stitch first and use it to lift the skin edges while the other half is inserted

the edges of an incision unless some steps are taken to prevent this happening The tendency can be counteracted by picking up the dermal layer only with the dissecting forceps instead of the whole skin and then entering the needle close to the cut edge before taking a wider bite of the dermis (Fig 90) Another method of



FIG. 93. Inserting all stitches together cutting the lot.

ensuring whole thickness apposition is to use right-angled mattress sutures, but even these should extend to no great distance from the edge (Fig 91) Other kinds of stitch are illustrated in the diagrams

It might seem that the continuous stitch would have much to be said for it, but in practice it is often found wanting A glover can be put in quickly and easily, but it causes puckering and allows protrusion of blebs of fat

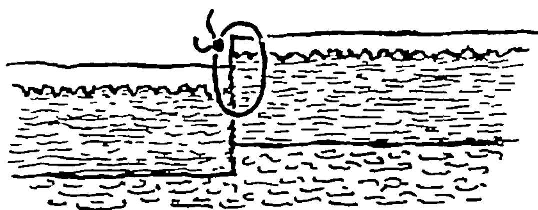


FIG 94 Stepping the skin, an easy mistake to make on the palms or soles, or anywhere where the skin is thick

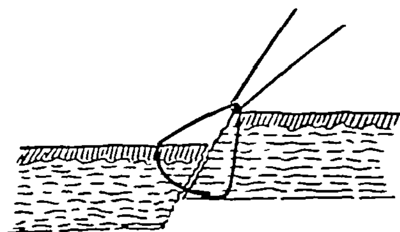


FIG 94A An oblique skin incision leads to overlap, the undermined edge necroses, granulations form, and keloid often follows

A blanket is better, but not entirely satisfactory Plastic surgeons, who should be good judges, rely on interrupted stitches placed close enough together to prevent the slightest protrusion of fat

Indisputably, interrupted stitching is a slow business, but it can be speeded up considerably if all stitches are inserted first, given to an assistant to hold aside until the time comes to tie them off one after the other and then cut in a row All knots should be tied to one side

and no stitch should be so tight as to cause blanching Blanching is an indication for cutting the stitch out and putting in a fresh one It must not be forgotten that a

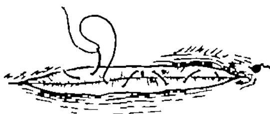


FIG 95 A subcuticular stitch anchored with a shot this is not a reliable type of stitch.

stitch which is tight on the day of operation will be twice as tight next day because of the reactionary œdema around it. This applies not only to the skin but to all sorts of sutures and ligatures in the deeper tissues if they are composed of non absorbable material catgut does not offend to the same extent because of its tendency to soften and stretch Even so it is safe to say that nine out of ten knots are tied too tight

Stitching under Tension This raises the whole question of stitching under tension There are many occasions when a surgeon is tempted to pull skin edges together to cover a defect When the tension is not very great the results may not be serious—perhaps no more than a line of granulations on the tenth day along a wound that should be dry by this time—but if the tension is sufficient to deprive the edges of their blood supply

(1) The edges will slough
(2) The wound will gape
(3) The whole wound will become infected.

The difficulty arises most often after a radical operation for carcinoma of the breast Here there is extensive undermining as an additional handicap to healing There

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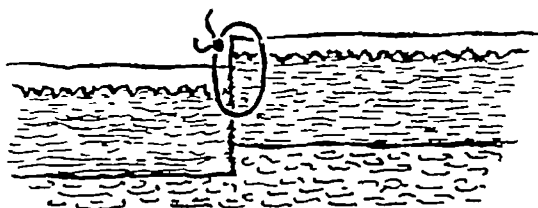


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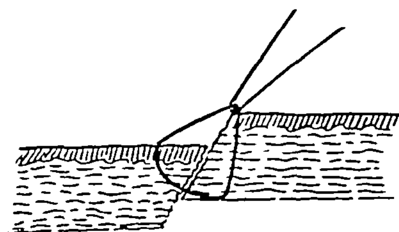


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the exposed and presumably infected part of the stitch is dragged through the depths of the wound A collodion dressing should be used for the next few days besides being protective it affords a mild form of splintage until healing is complete

can be no doubt that much heart burning would be saved in these cases if the flaps were brought together quite loosely above and below, anchored to the intercostal muscles to prevent respiratory "slide," and the exposed surface either left to epithelialise if it is of no great extent, or Thiersch grafted on the spot

Removing the Stitches It is not only the putting in of stitches but the taking of them out that decides how the scar will look when the patient gets a chance to inspect it

The trend nowadays is to remove stitches early On the exposed parts of the head and neck alternate ones may be taken out on the third day and the remainder on the fifth If there is any inclination for the wound to gape the second lot may be cut and left for a while longer, in this way the risk of hatching is overcome while the severed stitches remain to give support to the tissues When clips are used in combination with a platysma suture after a thyroid operation they should be dispensed with after forty-eight hours

In other parts of the body there need not be the same hurry to be rid of stitches, but few need be retained beyond the seventh or eighth day It is only the through-and-through tension sutures in threatened disruption that must be left for fourteen days

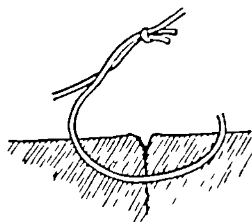


FIG 96 A stitch is removed by cutting under the laterally placed knot and pulling on the knot, this avoids dragging the soiled part of the stitch through the tissues

As a rule the actual removal of the stitches is left to the nursing staff For the sake of maintaining asepsis to the last it is important that whoever is responsible should realise the importance of cutting the stitch under the laterally placed knot and withdrawing it by pulling on the knot Any attempt to reverse this procedure means that

his theatre sprayed with carbolic during operations.[1] It soon became clear however that there were other and more prolific sources of infection than the air in the operating room and surgeons turned their attention to them and gave up the carbolic spray

Recent investigations have shown that Lister s fears were by no means groundless If a blood agar plate is exposed in a theatre during an operation and then incubated it will show quite a healthy growth next day and the growth will be ten times as thick when there has been a lot of conversation coming and going or general disturbance during the time of exposure It has been estimated that as many as 30 000 to 60 000 micro-organisms fall on the sterile field per minute in the course of an ordinary operation the figure varying directly with the number of people and the amount of activity in the theatre If however the count is taken when the theatre is empty and all the doors and windows are closed the result is quite different. There may in fact be no growth at all on the plate The explanation of this is that bacteria only become air borne on (*a*) droplets of moisture (*b*) particles of dust When there is no one about the droplets very quickly disappear from the atmosphere and the dust particles all settle on the floor

In many theatres the ventilation is haphazard An exhaust fan clears excess of steam and this is automatically replaced by currents of dust laden air sucked in through ill fitting doors Even when a special inlet is provided it is often inadequate A positive pressure system is much preferable Properly filtered air can then be introduced in quantities sufficient to maintain a positive pressure inside the theatre allowing for any exhaust that

[1] One of his house surgeons was forced to give up his appointment because he was sensitive to carbolic and passed olive green urine for twenty four hours after each operating session

CHAPTER IX

WOUND INFECTION

THAT ten per cent of all clean surgical wounds become infected is a shocking admission, yet one that must be made It is true that organisms are everywhere watching their chance to enter the body through the slightest breach in its defences But this excuse is not as good as it sounds Most of these organisms are destroyed by lysozymes present in all living tissue in other words, they are non-pathogenic And of the pathogens all but the streptococci must attack in force if they are to establish themselves , streptococci alone are capable of gaining a foothold when present in small numbers

This being so, the incidence of infection needs some explanation Leaving aside gross carelessness, here are some of the reasons why it is so high

How Wounds Become Infected (1) First, foremost, and all the time, comes the fact that the skin cannot be sterilised, and this applies to the surgeon's hands no less than to the part operated on No matter what care is taken, bacteria will escape destruction in the deeper recesses of the sweat and sebaceous glands, more in certain parts of the body than others, more in some people than others, more in the old than the young In the absence of sweating these bacteria may not emerge until near the end of the operation, but the blade of the scalpel used for the skin incision may be contaminated by them from the start All this has been proved by experiment

(2) Lister was greatly concerned with the dangers of air-borne infection, and tried to minimise them by having

his theatre sprayed with carbolic during operations[1] It soon became clear however that there were other and more prolific sources of infection than the air in the operating room and surgeons turned their attention to them and gave up the carbolic spray

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may be required Open doors, of course, introduce an unavoidable risk, but interchange through them is relatively slight compared to artificially created draughts

(3) Catgut is not invariably free from micro-organisms, even lethal ones like the tetanus bacillus But the most cursory processing will clear it of staphylococci, which are the usual culprits in wound infection It is not fair, therefore, to blame it immediately the edges of an incision begin to redden If it is really responsible for the trouble, then its chemical content is more likely to be at fault than its sterility An excess of chromic acid will act as an irritant and set up inflammation, interfering with absorption at the same time

(4) The operation itself may create conditions favourable to infection It is not easy to obliterate all dead space, and any that is left fills up at once with serum or blood, either of which is an excellent pabulum for bacterial growth Bruised tissue of any kind, particularly muscle, offers a similar hospitality to organisms The opening up of cellular planes by dissection or gauze stripping facilitates the spread of inflammation Even a minor contamination is sufficient to infect fat

(5) When the bowel is interfered with infection is only too likely to follow, although there may have been no gross soiling Any clamp used for crushing gut (or the appendix) becomes contaminated So very often does a suture (anastomosing, invaginating) used in gut, no matter how much care is taken to see that the needle carrying it does not penetrate the deeper layers The same thing applies to a suture used for anchoring colon, cæcum, etc , to the surface, especially when there is distension

Some Technical Precautions The following suggestions cover some details of aseptic technique that are occasionally forgotten —

(1) The naso-pharynx is the great reservoir of cocci,

but because of the continual commerce between hand and mouth in eating drinking smoking using a handkerchief etc the hands harbour almost as many cocci as the nasopharynx some people indeed are skin carriers of *Staphylococcus aureus* which fact may account for the bad luck of the surgeon whose cases always go septic[1] However about that there is no excuse for anyone engaged in surgery who adds to the flora on his own hands by doing rectal examinations without a glove removing soiled dressings without forceps etc

Washing up demands full attention This does not mean that the hands should be scrubbed until they are excoriated *If they are clean to start with* there is no need for a scrubbing brush at all Soap solution plus gentle massage will get rid of all the surface soil which holds the transient bacteria the deeper and more permanent residents are better left undisturbed. But the whole area between elbow and finger tips must be covered One author believes that parts often escape attention altogether to prove his point he suggests a trial wash up blindfolded after the arms and forearms have been swabbed with a mixture of salad oil and lampblack

Soap solution in a bowl is a better solvent than running water under a tap and five minutes is a fair time for the initial cleansing after that a good rinse should suffice. The dip in biniodide is a ritual gesture which in no way excuses any scamping of the washing When washing up is complete the surgeon s mackintosh is usually quite wet from splashing It should be thoroughly dried If it is not the gown soon becomes damp and another barrier to infection is broken down

Gloves should be put on in such a way as to protect

[1] The results of two surgeons operating on clean cases were examined. A had fourteen infected wounds out of fifty four B one out of fifty-one A was a skin carrier of *S aureus* (*Lancet* May 1939 1088)

their exteriors from any contact with hands or wrists And during the operation close watch should be kept for any punctures or tears in the rubber , after an hour or so



Fig 97 (a)

the contained sweat is bound to be heavily infected Sweat is not the only thing that can escape through a tear Dusting powder can too Talc has been demonstrated in post-operative peritoneal adhesions, in the walls of unhealed fistulæ, and in the fibrous induration around wounds

(2) An impervious mask covering mouth and nose and well tucked in under the chin should be worn. Ordinary gauze is not impervious to spray except in many thicknesses but a double thickness can be made so by slipping a piece of cellophane between the two layers. A person



Fig 97 (b)

Fig 97 (a) Blankets are better kept out of the operating theatre; certainly they should never be flapped. (b) The iodine swab should not touch the patient's gown.

with a cold in the head should stay out of the theatre altogether. If this is impossible he should pay very special attention to his masking, washing up, etc. It is significant that epidemics of wound infection often coincide with epidemics of nasal catarrh.

All talking should stop during an operation. Movement should be cut down to a minimum, especially in shifting the patient on and off the table, flapping of

blankets is peculiarly obnoxious Draughts, whether from open doors or windows, are anathema

(3) The skin of the patient will already have been prepared with some fat solvent followed by an antiseptic and covered by a sterile towel This must by no means be interfered with until the patient is in the correct position on the table and all clothing, blankets, etc , have been folded well back A final survey of the field of operation is sometimes rewarding The depths of the umbilicus may still be dirty It is no uncommon thing for the urologist to find on retracting the foreskin that the smegma of decades has not yet been cleared away Motives of delicacy discourage interference with this part of the body even by the patient himself Whether there has been any oversight or not, a point should be made in applying the final coat of antiseptic never to let a swab which has been in contact with a relatively dirty area, *e g* , the scrotum or neighbourhood of a sinus come into contact with a relatively clean area, *e g* , the skin of the abdominal wall It has been said that when everything has been done to clean the scrotal skin it should still be treated like the " dirtiest thing in the world ", but nurses have a touching belief in the power of antiseptics and may distribute its fauna all over the operation field on the end of a swab if they are not warned of the danger

As soon as the incision is made tetra, towels should be clipped to its edges in such a way that their outer surfaces never come into contact with the skin These are left in position until the time comes to put in the final stitches *No suture, ligature or instrument should ever be allowed to touch the bare skin* The correct length for a ligature is 12 in If it is any longer the slack is very apt to trail round the wound When several points are to be tied from the same length a bobbin should be used

(4) When bowel is being dealt with extra safeguards

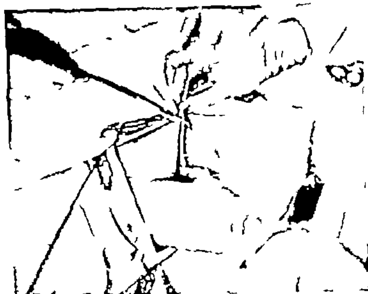


FIG. 98 Taking a deep two handed, bite with the tetra forceps when adjusting the skin towels so as to exclude not only skin but also subcutaneous fat from the field of operation.

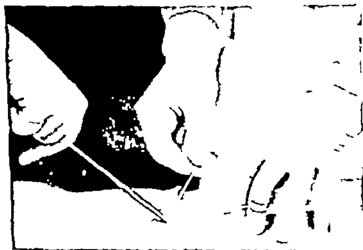


FIG 99 Failing a bobbin a two-handed knot can be tied quite neatly with the slack wound round the middle finger this method economises catgut and saves it from contamination.

are essential A red "danger" towel should be spread over the ordinary ones to quarantine the soiled instruments, packs should be arranged to isolate the anastomosis, and when it is completed all the paraphernalia should be put aside and not used again without resterilisation Some surgeons rely on a spray of penicillin sulphathiasol powder as a final safeguard, or put the patient on a course of penicillin Adequate preparation of the bowel with sulphasuccynil has, of course, reduced the risks in these cases

(5) The need for gentleness and complete hæmostasis should be constantly in mind All exposed tissues should be covered with warm, moist packs All dead space should be obliterated before the wound is closed If this cannot be done drainage and a pressure dressing should be employed The axillary space after a radical breast operation is a case in point It can be largely obliterated by a ball of gauze firmly bandaged into the axilla, but drainage is necessary as well

(6) Some surgeons rely on a spray of penicillin sulphathiasol powder, or start a course of penicillin as a routine, especially when dealing with fat patients In this connection it is worth remembering that between thirty and seventy per cent of cocci cultured from the nasopharynx of hospital staff may be penicillin resistant

(7) Infected matter should be got rid of as quickly as possible by means of a strongly acting sucker In surgery many complications arise from neglect of the domestic virtues of cleanliness and tidiness Pus slopping on to the floor may dry and disseminate its organisms all over the theatre

(8) The prevention of infection is a group responsibility Unfortunately not all of the people involved have a working knowledge of bacteriology The responsibility lies all the more heavily on the instructed few

CHAPTER X

ORTHOPÆDIC SURGERY

By DAVID LE VAY M S F R C S

Skin Preparation Though it is traditional to begin skin preparation forty-eight or even seventy two hours before any major orthopædic operation it is doubtful whether this is justified There is no bacteriological support for the belief that time and repeated antiseptic applications improve the disinfection of the skin and the delay often allows razor scratches to become mildly infected If the part is carefully washed with soap and water using a soft brush and then painted with 1 per cent cetavlon this should be sufficient It is another matter when a limb has been encased in plaster for many weeks and the skin is encrusted and scaly then several days sponging with olive oil may be needed to bring it into a healthy condition

Nowadays pressure on bed space often makes it necessary to perform minor operations on out patients This can be done with safety if the patient comes up to hospital for preparation on the day before operation and again on the morning of operation the limb being securely bandaged in a sterile towel meanwhile Removal of ganglia exostectomy for hallux valgus and incision of stenosed tendon sheaths can be carried out in this fashion without ill results

In emergency surgery for open wounds compound fractures or burns no cleansing of any kind should ever be attempted in the ward for it is there that the first streptococcal infection may be implanted from the attendant s throat The limb should be merely wrapped in a

sterile towel with a pad of sterile gauze over the wound In the theatre the masked and gloved surgeon will then clean the surrounding skin with soap and water and cetavlon, leaving the pad in place until it is time to clean the wound itself Even severe hæmorrhage is no reason for upsetting this routine, for the hæmorrhage can usually be checked by tight bandaging over the pad, a safer and more effective method than tourniquet control

Anæsthesia Certain special points arise in connection with anæsthesia for orthopædic operations

Manipulation of the spine and larger joints should always be done under intravenous pentothal, and enough of the drug must be given fairly rapidly With slow administration of an inadequate dose relaxation is incomplete and laryngeal spasm is provoked, then when manipulation is attempted the musculature becomes rigid and it is impossible to complete the procedure without resorting to full inhalation anæsthesia Dosage is important because the main risk of damage comes from inadequate relaxation, and this applies particularly to the spine and shoulder If it is desired to have the patient's active co-operation in performing some movement soon after regaining consciousness it is wise to give no preliminary sedation

Complete relaxation, as for abdominal work, is seldom essential in orthopædic operations It is required, however, in laminectomy to relax the erectores spinæ, in operations when the hip has to be forcibly dislocated, and in some operations on spastic patients where the extent of fixed contracture can only be assessed after eliminating all traces of muscular spasm

Spinal anæsthesia for work on the lower limbs has little attraction for the orthopædic surgeon, because it leaves a lowered muscular tone for some days afterwards, but there is an occasional indication, [illegible] when a low

unilateral spinal enables one to operate on the knee of a patient with chronic pulmonary disease

Brachial plexus block is sometimes valuable for arm operations in elderly or poor risk cases or when it is felt desirable to identify tendons by voluntary contraction during operation or when several manipulations of a fracture with X ray checking are likely to be needed It is sometimes said that patients will not tolerate an occlud ing sphygmomanometer cuff under plexus anæsthesia alone but this is not the case

An intra tracheal tube must be used fairly frequently even for minor procedures if they are to be conducted in the face-down position Excision of the elbow joint or exploration of the popliteal fossa are examples It is needed also for operations about the head and neck such as removing the temporo-mandibular meniscus or explor ing the posterior triangle when it is important to exclude the anæsthetist from the sterile field

The anæsthetist has some important general duties in supervising transfusion and supportive treatment during long and potentially shocking operations such as arthrodesis of the hip joint Before any hip or spinal operation the patient should be grouped and blood made available rhesus grouping being taken into account for a woman of childbearing age If during operation rapid blood loss occurs the loss must be made up at the time and not after an interval.

It may often be necessary to continue full anæsthesia for a considerable period after stitching up as for instance when a tendon suture or bone-grafting needs protecting with plaster Premature recovery and movement may spoil everything in such cases

The Bloodless Field Whenever possible it is desirable to operate in a bloodless field A limb can always be exsanguinated by holding it vertically in the air for five

minutes and then applying some form of tourniquet If the preliminary elevation is omitted the exsanguination will be incomplete, and venous thrombosis may result

When any form of rubber tourniquet is used the skin should always be protected by several turns of towelling But the ordinary form of rubber tourniquet is now relegated to first-aid work and either a pneumatic tourniquet or an Esmarch bandage are provided in every up-to-date operating theatre A sphygmomanometer proves perfectly satisfactory for the arm, but a special pattern is needed for the leg and, as this is not usually available, an Esmarch bandage takes its place If an Esmarch is used on the arm it may easily damage the musculo-spiral nerve

Whichever is used should be adjusted well up into the axilla or groin There are two reasons for this First and most important—the essential corollary to tourniquet control of bleeding is an efficient pressure dressing applied at the end of the operation before the tourniquet is released , such a bandage cannot be put on properly unless there is plenty of room above and below the operation site Thus, after excising a semilunar cartilage it is most important to apply a really firm pressure bandage over a large amount of wool as soon as the wound is closed Such a bandage cannot be applied efficiently unless it is carried up almost as high as the groin, and a mid-thigh tourniquet makes this impossible The second reason for a high tourniquet is that it can exert no harmful pressure on the nerves which come to the surface near the elbow and knee

When the cuff of a pneumatic tourniquet is in position the mercury should be pumped up to 180 mm The limb can then be lowered and prepared Since it is a nuisance if the pressure falls and allows bleeding during an operation it is wise to take precautions against air

leakage by tying a cotton bandage over the cuff and securing the two rubber tubes with a large hæmostat

An Esmarch bandage should be of real rubber the synthetic type often rolls itself up into a thin and dangerous ligature For any operation above the foot it should be wound tightly round the whole limb from toes to groin Because it is unwrapped from below upwards the turns must not overlap or it may be very difficult to undo them At the groin the bandage is stretched round the thigh as tight as it will go with a folded towel four layers thick underneath to protect the skin Then the remainder is unwound from below upwards

It is not necessary to carry an Esmarch bandage up to the groin for minor operations on the toes or feet Mid calf is high enough If it is tightened higher up in the danger area round the knee the common peroneal nerve may be compressed against the head of the fibula Even in the calf the stretching should not be overdone and a folded towel should always be used under the rubber any carelessness may result in troublesome paræsthesiæ later An Esmarch bandage is not suitable for use in inflammatory conditions it may easily squeeze infective material into the circulation Elevation of the limb followed by some form of high bandaging is usually all that is needed

A tourniquet should never be left on longer than an hour and a half and this may be too long in many cases The state of the tissues the condition of the vessels the presence or absence of anæmia and other factors as well must be reckoned with in gauging the margin of security It is safer not to use a tourniquet at all in patients over fifty or where there is any fear of gangrene either from gas infection or other cause Bleeding can be controlled in these cases by digital pressure on the main artery of the limb

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placed under the part it has the additional advantage that it prevents contamination spreading up through a sodden towel

Wound towels must be applied accurately so as to cover not only the skin surface but also the cut thickness of the skin So they should be folded in over the edges of the incision and clipped there with forceps which hold them snugly against the under surface of the flap and placed sufficiently close to each other to prevent any bulging into the operative field Moynihan s forceps are ideal for this purpose forceps of the Allis type tend to cause distortion Skin and towels should be carefully dovetailed at each end of the incision The alternative method of making the incision through a layer of stockinette or an actual stocking glued to the surface is not as effective as it appears because cut edges are left exposed and with them sweat and sebaceous glands which harbour micro-organisms

The No Touch Technique The young surgeon must decide for himself whether he is going to adopt the no touch technique or not Strictly applied the method is exacting and requires constant care Neither the patient s skin nor tissues nor anything that comes into contact with them must be touched by anyone Surgeon and sister may handle only the butt end of the instruments needle threading ligaturing suturing screwing and drilling must all be done with instruments These rules were rigidly obeyed at one time but with the manufacture of good rubber gloves it was realised that such extreme precaution was not necessary and the modern orthopædic surgeon allows himself a good deal more latitude

Nevertheless the idea remains a good one Handling of tissues and instruments should still be kept to a minimum the patient s skin should never be touched and

When a patient is admitted to hospital with a hopelessly mangled limb in which hæmorrhage has been controlled by a tourniquet this should not be touched until the limb has been removed If it is taken off earlier circulatory collapse may ensue due to loss of plasma into the damaged tissues

It is a wise safeguard to have a red light in an operating theatre where tourniquets are commonly used This can be switched on when the tourniquet is applied and switched off when it is removed An alternative is to tie one end of the tourniquet—if it is an Esmarch—to the operating table It is then impossible to send the patient back to the ward without taking it off

Case Note A tourniquet was applied by an anæsthetist as a preliminary to the removal of a cartilage As soon as the operation was complete the anæsthetist left for another hospital without removing the tourniquet, which was now concealed under the towels The patient recovered consciousness in the ward, complained of pain, and was given an injection Another injection was given a couple of hours later Another two hours elapsed, and the patient complained once more The tourniquet was then discovered and removed Symptoms of a crush syndrome developed, and death occurred after an interval of nineteen days

The case illustrates the dangers of the divided responsibility seen so often in a fully staffed theatre The person who puts a tourniquet on should make it his obligatory duty to take it off And when a patient complains of pain it is always worth glancing at the part he complains of before giving him a dose of morphine

The Towel Drape In orthopædic cases it is frequently necessary to move the part or limb during the course of an operation This must be taken into account during the preliminary draping of the sterile towels by allowing enough latitude to prevent any gap appearing later on As an extra precaution a sterile mackintosh should be

above all gloves should never be put on in such a way that their outer surfaces are fingered This latter rule is often broken and the results may be so disastrous that the author may be forgiven for including here illustrations of the proper procedure



FIG 100

Even the best gloves may be damaged during an operation The risk is defined by an investigation reported in the *Lancet*[1] Some thousands of gloves were examined after use Twenty four per cent were found to be perforated or torn Then the surgeons concerned were warned and asked to be more careful Even so the percentage remained as high as fourteen[2] Obviously in cases in which the possible consequences of infection are so grave the only safe thing to do is to keep

[1] *Lancet* 1939 1033

[2] The surgeon who finds blood on his fingers when he removes his gloves may be sure that the worst has happened.

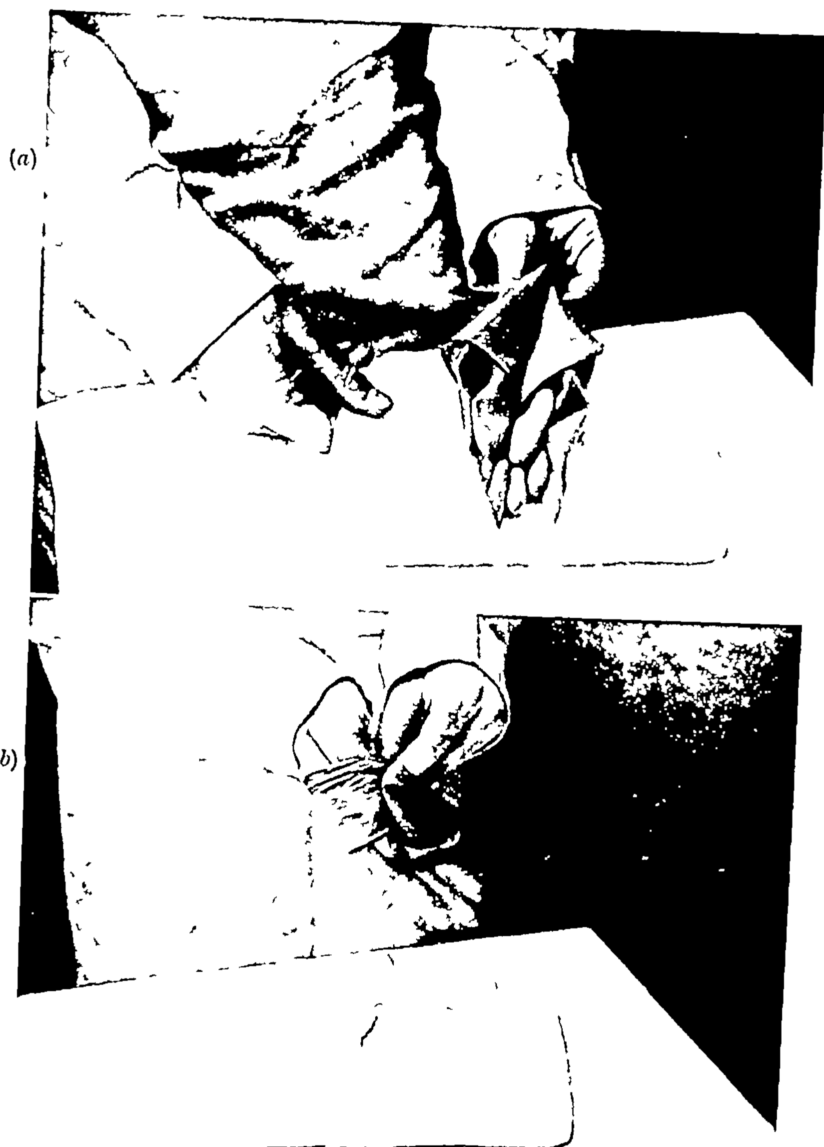


FIG 100

the gloves away from the wound as much as possible or from anything such as a suture a ligature or the end of an instrument that makes contact with the wound



Fig 100.

Fig 100 Putting on sterile gloves. Gloves and powder puffs should be taken from separate drums by a nurse using pickers.

(a) Left hand used to withdraw gloves from packet.
(b) Right glove is drawn on.
(c) Fingers of right hand inserted under reverse of left glove which is drawn on the thumb is not used.
(d) Wrong method of drawing on glove—thumb is touching skin.
(e) Right hand gathers left sleeve tightly around wrist, where it is held by pressure of right thumb Reverse of left glove is turned up working from inside it. Right thumb must not be used to help Similarly with right glove.
(f) Wrong method of turning up reverse.

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Incisions and Approaches Orthopædic approaches should be simple and direct but taking advantage of inter muscular clefts and fascial planes where this is possible A curved incision is sometimes advised for operations on

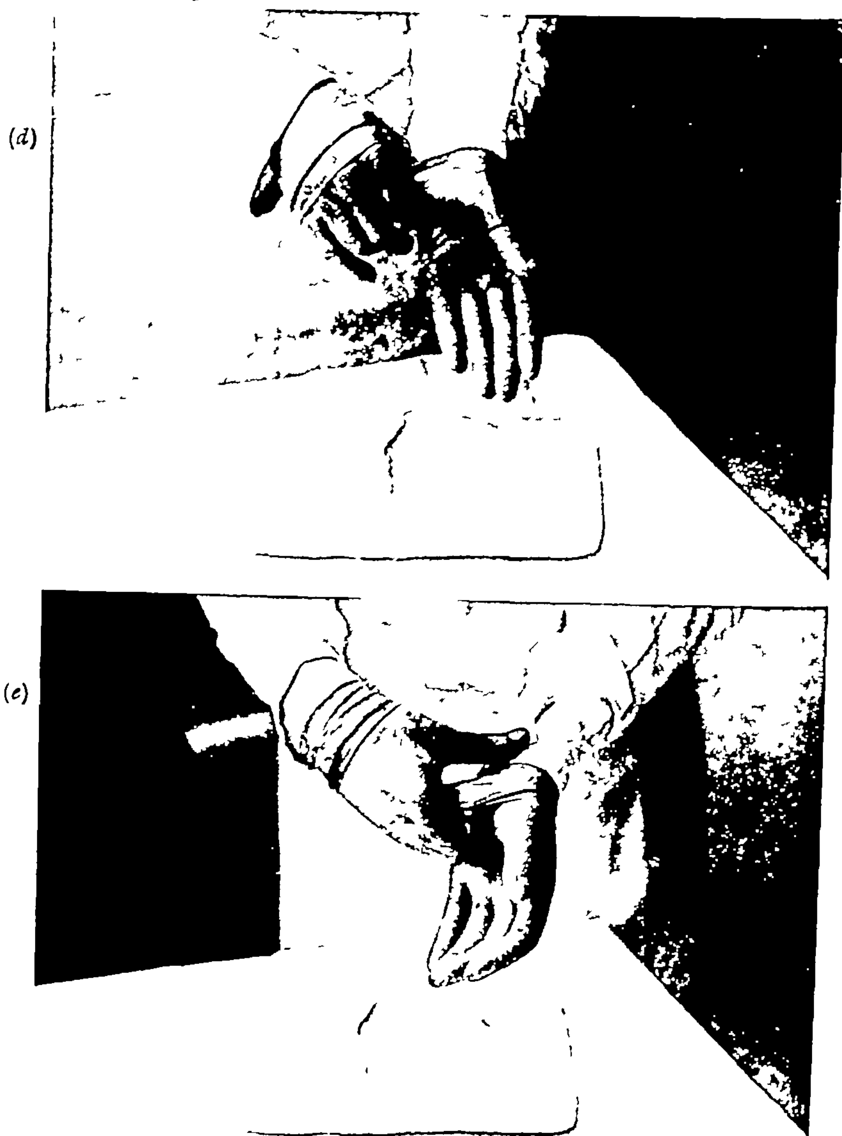


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the spine, taking of tibial grafts, or fixing a fractured malleolus, with the idea of keeping the scar away from the bony prominence Actually a short straight incision immediately over the prominence proves more satisfactory When, however, it is a matter of removing a bony mass, it is sometimes better to break this rule For instance—the obvious incision for removing a bunion is right over it, but if instead the cut starts further back and ends just at the swelling, a chisel can be laid flush with the shaft of the bone and the exostosis removed at its neck The other approach tends to give insufficient elbow room

Two other points about the skin incision It must be so ample that the operation can be completed without risking the introduction of sepsis by having to remove the towels in order to extend the wound Therefore, after making what you consider an adequate incision always make it a little longer This is particularly important in exposing a fracture, because it is often surprisingly difficult to judge the position of the fracture in relation to the centre of the incision

The second point is that the knife used for the skin incision must be discarded and never used in any other plane Organisms can be cultivated from the blade in too high a percentage of cases—20 per cent —to make the risk of continuing with it at all justifiable

It is never safe to use a slender blade or a detachable blade of any kind near a bone or inside a joint , the tip might easily break off and get lost during such procedures as the exposure of a fracture or the removal of a semilunar cartilage The change of knife, therefore, gives the surgeon an opportunity to select a solid, one-piece scalpel for use during the rest of the operation

The manner in which the dissection proceeds depends on the nature of the operation and the temperament of the operator "Get down to bone and stay there" is

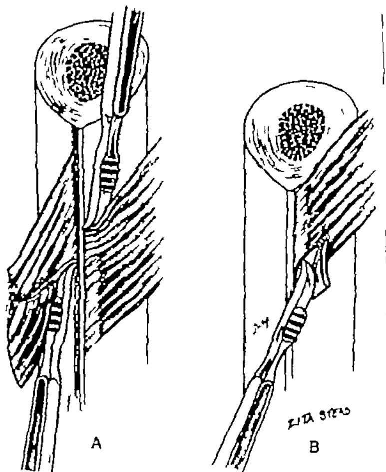


FIG 101 (*a*) Work the rugine into the acute angle which fibres of muscle or interosseous membrane make with bone (*b*) Shows how the rugine tears into a muscle when used in the reverse direction and against the obtuse angle (*Arnold Henry Extensile exposure applied to limb surgery* L & S Livingstone Ltd Edinburgh)

the orthopædic watchword When it is possible to do this the scalpel can be used boldly to expose bone and the broad chisel to strip periosteum with its attached muscles a chisel is a better instrument than a rougine for this purpose In the upper part of a Smith Petersen incision for example the iliac crest can be laid bare at

once, and the periosteum reflected in one piece with the gluteus medius, in a laminectomy the separation can be carried straight down to the spinous processes and the erector spinæ muscles reflected on either side with the periosteum from which they rise In both cases oozing can be satisfactorily stopped by tight packing with really hot packs But an error of a few millimetres to one side or the other with the incision is enough to make the procedure a bloody one because the cut then passes through muscle instead of under periosteum Henry gives a practical tip about the actual stripping of the periosteum He points out that the chisel should be worked into the acute angle of attachment of the muscle fibres, if it is worked in the opposite direction it tends to slip off the bone into the flesh, and a ragged, bleeding field results

In dealing with a long bone the periosteum can usually be reflected and levers slipped under the shaft so that the soft tissues are held well back and the operative site is cleared without danger to any important structures Notice that the levers lie *under* the periosteum Their ends should be blunted and rest against the bone for leverage and not amongst the tissues If they can be passed right through behind the bone what at first appears to be rather a deep and inaccessible operation site may be brought up to the surface This is often the case in the forearm

One must always bear in mind the nerves in the vicinity when exposing bone, the ulnar at the elbow and the common peroneal at the knee are particularly vulnerable There are two ways of avoiding trouble One is to incise clear of the nerve, go down to the bone, hug it closely, and complete the exposure by meticulous sub-periosteal stripping, the other is to dissect out the nerve at the outset and hold it out of harm's way Thus in removing

the head of the radius the deep branch of the radial is in no danger if the incision is prolonged no lower than the neck of the bone. But if the whole upper third of the radius must be exposed the right way to proceed is to cut down on the subcutaneous border of the *ulna* strip outwards first the anconæus and then the whole origin of the supinator brevis so carrying the nerve safely forwards between the two layers of muscle.

Drilling Screwing Plating The ordinary rules of the workshop apply with some modification to mechanical procedures on bone.

(1) The drill should be properly matched with the screw to be inserted. Otherwise the screw will either not fit at all or will slip through without gripping. The drill must therefore be of the same diameter as the shaft of the screw or a little smaller. The screws should be threaded right up to the head a coarse thread of the Venable type being much better and easier to manage than the fine Sherman variety.

(2) In using a drill the hole must be started with the drill at right angles to the surface of the bone. If obliquity is required the direction can then be changed. To begin drilling obliquely usually means that the point slides off into the tissues. Alternatively a sharp awl can be used to give a safe start.

(3) Only a gentle constant pressure against the drill stock is required. With anything more than this or any impatience or jerking the drill breaks off flush with the shaft and it is impossible to remove the fragment without inflicting a lot of damage. If it is left it appears on every X ray plate taken subsequently as the sign manual of an incompetent surgeon.

(4) It is much quicker to use a drill mounted on the socket of an electric or pneumatic saw but with such an appliance it is still easier to blunder. Special care must

be taken not to slip off the bone, over penetrate the opposite cortex, or work at a speed that generates enough heat to burn or char the edges of the hole

(5) It is essential to engage both proximal and distal cortices of the shaft so that the tip of the screw will just emerge on the far side of the bone, to go further serves no useful purpose and may endanger vessels and nerves The length required must be accurately estimated, either

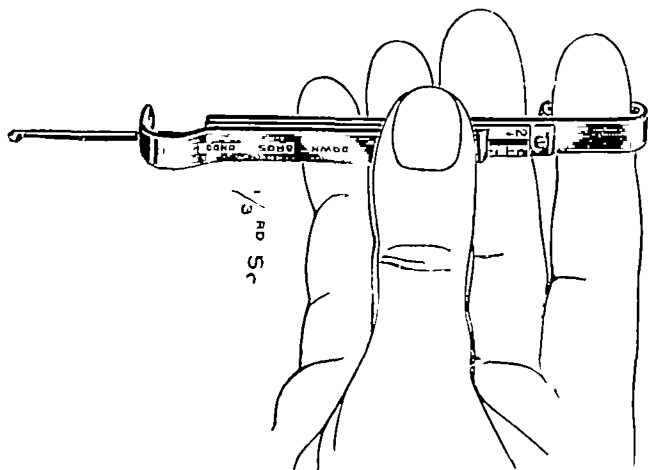


FIG 102 An Adams' calibrator (*By courtesy of Messrs Down Bros*)

with a probe or a simple calibrator like the Adams' The direction of the drill hole must also be determined with a probe before inserting the screw, otherwise its tip may miss the hole in the opposite cortex and fail to make further progress, nothing is more embarrassing in fixing a fracture than the "starting" of the plate when this

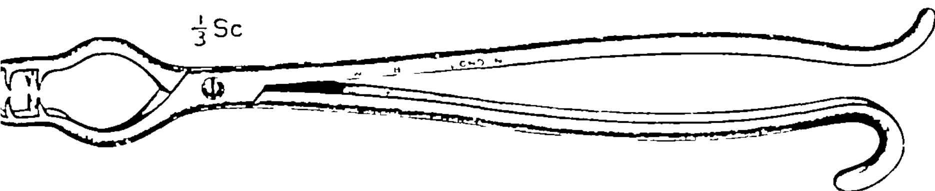


FIG 103 Lane's bone holding forceps (*By courtesy of Messrs Down Bros*)

happens the heads may even be torn off other screws already in place

(6) In plating a fracture all screws should be parallel and in the same plane not as sometimes advised in different directions and planes

(7) Lane's holders are still the best instruments for handling a screw and the most satisfactory screwdriver is one of the Burns type which grips and encloses the head and effectually prevents it from slipping

(8) Of the larger variety of bone plates the simple flat Venable vitallium plate is very satisfactory Though it is not essential to use vitallium for a good stainless steel

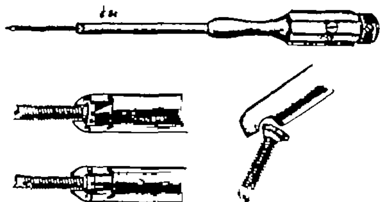


FIG 104. Burns screw driver (*By courtesy of Messrs Down Bros*)

will do just as well what is important is never to use plates and screws of different materials If this is done electrolytic changes occur between the two metals and this causes osteoporosis round the screws which may as a result come adrift at the same time the vitality of the bone ends may be diminished so that union of the fracture is interfered with All this is well known yet it is often not until half way through an operation that the discovery is made that the only plates and screws available are of different materials A routine check of equipment should always be carried out beforehand.

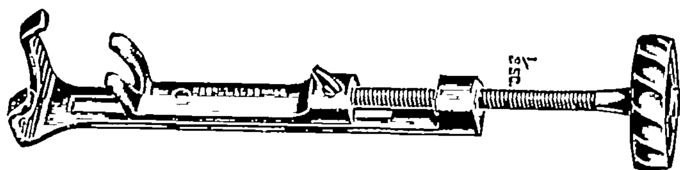


Fig 105 Lowman's clamp (*By courtesy of Messrs Down Bros*)

(9) When plating a fracture the essential steps are good *subperiosteal* exposure of the bone, anatomical reduction of the displacement, locking of plate and fragments in position by a clamp of the type illustrated, and firm screwing If reduction is at all difficult Lane's manœuvre of bringing the two ends out of the wound and fitting them together so that they lock automatically on being replaced is excellent It may be that the plate (which should always be placed on a muscular and not a subcutaneous surface) does not lie altogether smoothly when placed against the shaft This should be corrected before starting to screw, because while the screws will pull down and bend a vitallium plate safely enough, a similar

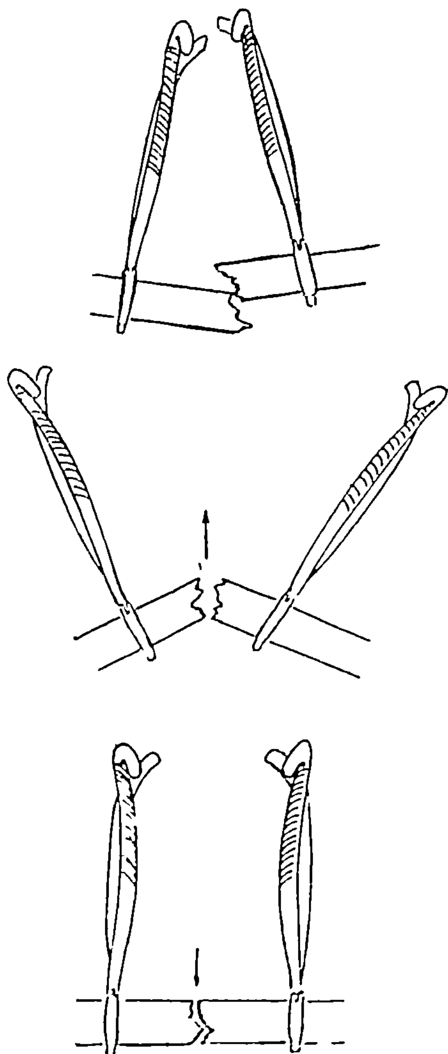


Fig 106 Lane's manœuvre for reducing a displacement

strain on a steel plate may cause it to break though this may not happen until several weeks after the operation A sandbag behind or beneath the limb provides the counter pressure required during the screwing It is best to begin by placing the intermediate screws on either side in order to stabilise the plate and fracture and then to follow with the others alternating the sides No screw is driven right home until all are inserted then each is tightened a few turns at a time as with the nuts on the wheel of a motor car *Any plating which ends with the fragments held* even a very short distance apart is unbiological and invites non union

Osteotomy The conventional instrument for this procedure is a sharp osteotome but it has the disadvantage that it may cause splintering and fissuring In some bones notably the femur it may be helpful to outline the direction of cut in a gentle curve with a series of drill holes and to make the section with a wide gouge

A chisel laid flat with the shaft is used for removing exostoses In the case of the common bunion the blade should be directed outwards so as to remove a larger portion of the metatarsal head

Bone Saws Bone saws whether electric or pneumatic should be tested before the anæsthetic is begun They are temperamental and if they fail to work when called on the operation may have to be abandoned.

Most saw blades rotate in a clockwise direction as the surgeon sees them and there is a dangerous tendency for the powerful force to run the blade off to the right Very serious damage to the soft tissues or the assistant s fingers may result Therefore it is wise to reverse the saw and cut from right *to left instead of left to* right *This is bad for the* blade and bad for the motor but it is safer for the patient

The speed should be sufficient to give easy cutting without running the risk of charring the bone.

Any temptation to use the saw for rounding off corners should be resisted, the blade breaks before it bends and the fragments fly off at high velocity

Bone Grafts Spontaneous fracture may follow removal of a bone graft from the lower half of the tibia, there is less danger of this if the graft is taken from the upper half It is impossible to suture the periosteum after removing such a graft, and no attempt should be made to do so Only the skin needs stitching And as there is a considerable danger of a hæmatoma forming, a really firm pressure dressing should be used to prevent this happening

If the ilium is used as a source of cancellous bone, it is best to perform subperiosteal reflection on both superficial and deep aspects of the crest, to remove with a gouge and discard the compacta and the crest itself, and then to take successive layers of the spongialis In this way suture of the gluteal to the abdominal muscles is made easy

All bone grafts should be kept dry pending use and not immersed in saline, which washes out useful material

Sutures and Ligatures Infection is disastrous in orthopædic work, and the risk of infection is increased by the use of catgut, which excites an œdematous reaction in the tissues It should therefore be avoided as much as possible A fine non-absorbent material is preferable Coats' No 40 black cotton is suitable for tying most small vessels, but No 20 may be needed for the larger Cotton ligatures can and should be cut flush with the knot, catgut ligatures need a few millimetres latitude The No 20 cotton can be used for suturing generally, but will not do for the synovia of joints, here catgut must be employed, but it should be plain and not chromic, or thicker than No 1 In everyday practice catgut is only permissible for closing the capsule of the knee joint As with all deep sutures, this one should never be allowed to touch the skin while it is being inserted

Hæmostasis When operating in a bloodless field it is usually unnecessary to pay much attention to cut vessels provided an efficient pressure bandage is applied before the tourniquet is released Of course considerable vessels must be tied As in all surgical operations sound anatomical knowledge enables one to seek and underrun these before they are cut *e g* the branches of the lateral circumflex artery and vein running transversely between tensor fascia and sartorius in the vertical limb of the Smith Petersen exposure of the hip joint

When a tourniquet is not in use all bleeding points must be picked up with artery forceps. If these forceps are left until the end of the operation it will be probably found that the bleeding does not recur when they are taken off because the crushing will have sealed the tiny lumina of the vessels meanwhile the forceps will have acted as evertors of the skin edges Bigger vessels must be ligatured and it is as well to do this as soon as they are divided so that they shall not be overlooked later on

When the towels are removed the surrounding skin should not be cleaned up with wet swabs if this is done infection may be washed into the tissues and in any case the wetting makes it difficult to apply an adhesive dressing

The most useful routine stitch in orthopædic work is the continuous eversion which gives perfect apposition of the skin edges and compresses all the small subcutaneous vessels. But experience is required to judge the right tension and if post-operative swelling is expected it is safer to use an interrupted stitch otherwise there may be some marginal necrosis

It is always a good plan to lay a narrow strip of gauze soaked in collodion along the wound This completes the sealing process

After such an operation as arthrodesis of hip or knee

the part may have to be immobilised in a plaster cast for many weeks There need be no concern about the stitches in these cases , they can be left until the plaster is taken off without ill effects

Prophylaxis of Infection. No mention need be made here of the use of sulphonamides and antibiotics in treating established infection More debatable is their routine use in prophylaxis of wound sepsis in clean orthopædic procedures Sepsis is such a disaster when it occurs that at first sight there seems to be an overwhelming argument for local and systematic chemotherapy in every case Unfortunately human nature is such that the use of this safeguard results in a relaxation of standards of aseptic technique and a carelessness in handling tissues and instruments It is important to be aware of this and not to expect modern drugs to make up for careless methods, if only for the reason that infection with penicillin-insensitive or Gram-negative organisms is still possible It would therefore be quite out of place to use chemotherapy for the removal of a knee cartilage, because with reasonable care these cases never become infected But it is sensible to take precautions in any extensive procedure, such as on the hip or spine, and whenever there is a particular reason to fear sepsis, such as in operating on a chronically inflamed bunion or on an old case of osteomyelitis, or in the presence of sinuses

Locally, a penicillin/sulphathiazole powder can be used in the wound before skin closure, or at all levels when several muscular planes have been opened, as in nailing a fractured femoral neck The real risk of intoxication from using an excessive amount in young and old patients and the danger of chronic granulomatous reaction if the powder is made up with talc should be remembered

Systematically, there is no point in giving penicillin pre-operatively, for what matters is to saturate the post-

operative wound hæmatoma with the drug and this can be done by giving 200 000 units intravenously towards the close of the operation followed by 30 000 units four hourly thereafter

Penicillin sensitivity is quite common nowadays and should be treated with anti histamine drugs If it is known that a patient is sensitive the fact should be recorded in his notes Otherwise he may get a severe skin reaction if the drug is used in an open wound

Bandaging and Plastering After an operation in a bloodless field the compression bandage must be applied to the limb before the occluding apparatus is released. It has two functions—to prevent bleeding and to splint the part in such a way that it can be moved and exercised without pain Following removal of a semilunar cartilage from the knee the prevention of post-operative effusion and the proper exercising of the leg depend largely on the way the bandaging has been done In such a case two or three large rolls of cotton wool should be applied from groin to ankle and secured by the same number of domette bandages wound as tightly as possible All the slack must be taken up in each turn of the bandage and a great deal of strength expended if the cotton wool is to be packed really tightly A cotton bandage will always break under the strain In other situations as on the feet and arms the best packing material is tailor s cellulose wadding which is put up in convenient rolls

Positioning the bandaged limb in the ward is important After cartilage operations the knee is allowed to sag straight by placing pillows behind foot and calf *only* Once an arm is bandaged the elbow flexion must never be increased or the circulation may be obstructed

When a plaster has to be applied after an operation the turns of the plaster bandage should never be pulled tight on the wool to help the hæmostasis Compression is

achieved either by a preliminary domette bandage or by gently moulding the completed plaster case to the contours of the limb With arthrodesis of the smaller joints it is usual to take off the plaster case after two weeks, remove the stitches, place the joint in its permanent position, and then apply a skin-tight plaster This type of plaster should not be applied immediately after an operation , the expert may take such a risk occasionally, but the novice is never justified in trying to copy him Some surgeons indeed make a practice of splitting even a padded cast before the patient leaves the theatre, and this certainly makes for safety, especially if the patient cannot be kept under observation afterwards But really efficient elevation of the limb—and this is just as necessary whether plaster is used or not—keeps œdema down to a minimum, so that splitting, which always impairs proper fixation, may be dispensed with Elevation does not mean the half-hearted propping up of an arm or leg on pillows The arm must be suspended vertically from a stand, and the leg from a Balkan beam at an angle of at least 60 degrees to the bed

If worries about the circulation in the limb make it necessary to cut the plaster, this must be done from end to end and the underlying bandages and wool also cut to expose the skin, for even strands of blood-soaked dressing are dangerous if they encircle a swollen limb

CHAPTER XI

WOUND SURGERY

PROVIDED the patient is in no danger from shock either present or threatening the sooner a contaminated wound is dealt with the better No exact time limits can be set but it is probable that at the end of six hours although there may be no great change in the appearance of the wound apart from some superficial glazing organ isms have already established themselves in the tissues and after eighteen hours they have begun to spread along the cellular planes and lymphatic channels. Of course there are exceptions to these rules cases of gas gangrene for instance obviously do not conform to them But by and large one can say that it is obligatory on a surgeon to wait some hours while treatment is being carried out for shock once shock is overcome the sooner he operates the better after eighteen hours any effort he makes at eliminating infection will do more harm than good

Early Cases Apart from treatment for shock and the taking of all necessary X rays these patients are better left in peace until they are under an anæsthetic on the table Then a nurse can take off the splints remove the dirty clothing and cover the wound with a fresh sterile dressing while he prepares the surrounding skin as for any other major operation No tourniquet is used for fear of gangrene

The surgeon now takes charge by draping the operation area in the usual way Ample exposure is absolutely essential and in war injuries this almost always means that the wound must be extended because *the deep destruction tends to be so much more widespread than the*

superficial When the whole area is fully displayed the first stage of the operation is completed by excising a narrow selvedge of skin, where it is soiled, and clipping on the wound towels

The next layer of subcutis and fat offers little resistance to infection and is easily replaceable, so it should be cleared away freely wherever it shows signs of involvement Deep fascia, now revealed, is split with a scalpel to the full extent of the wound, not only for the sake of exposure but also to relieve any tension that may develop later on

This permits a thorough exploration for foreign bodies, etc X-rays will help in the search, but such things as bits of clothing, slivers of glass[1] and splinters of wood are permeable to the rays, and must not be overlooked because they happen to be non-opaque Ambroise Paré, one of the first surgeons to record his experiences of this kind of work, left an injunction concerning it to his successors —

" and rather believe the judgement of your fingers than your probe "

His advice is still sound and applies to other things besides war surgery It does not pay, however, to open up fresh tissue in order to find a distant and elusive foreign body Usually it is better left, at least for the time being, especially when it is smooth surfaced like a bullet and unlikely to have carried cloth with it on its journey

Formerly it was the custom to remove all damaged or loose bone from the wound Impressed by the effects of penicillin surgeons have now become less pessimistic about the fate of these fragments Any attachment to periosteum or soft parts justifies leaving them, and in many cases totally separated pieces have survived, acting as a free bone graft

[1] Only glass containing lead, *e g* , bottle glass is radio opaque

Because of the threat of infection from gas-forming organisms the chief anxiety during an operation of this sort must be with muscle particularly damaged or avascular muscle in which such organisms flourish exceedingly That is why the Medical Research Council in its Memorandum on the subject lays down Any alteration in the appearance of muscle loss of contractility to mechanical stimulation or failure to bleed demands wide excision of this most vulnerable tissue Intermuscular spaces must be opened up and blood clot removed since these constitute an ideal pabulum for bacterial growth. [1]

Shoulder buttock thigh and calf are peculiarly liable to develop this form of infection and should receive special attention if they are involved

Fortunately for the patient the nerves tendons and aponeuroses because of their more compact structure do not offer the same hospitality to organisms that muscle does and superficial cleansing of them is all that is required Only in the very earliest and cleanest cases however should any attempt be made to suture tendon or nerve (see Chapters XIII and XIV)

It usually happens that more or less bleeding is excited by the steps described Every effort should be made to check it by packs forci pressure etc without using ligatures Buried catgut is most undesirable in these potentially infected wounds

If there is a fracture it will be necessary to reduce displacement The plaster case which is put on at the end of the operation will maintain the position. Alignment may not be perfect but it is better to wait until the threat of infection is past before resorting to any more drastic means of correcting it

The whole area is now dusted with penicillin powder Next comes the question of drainage Only in the most

[1] M.R.C. Memorandum No. 13

exceptional cases, in which the surgeon is absolutely confident that he has got rid of all infective material and every particle of damaged tissue, is he justified in closing the wound completely , even so it must be carefully watched and re-opened at the slightest sign of trouble In other cases, and these form the big majority, drainage should be as free as possible, *i e , the wound should be left entirely open* No deep sutures, fascial sutures, or skin stitches are permissible until it is clear that the danger of serious infection is past And a dry gauze pack is so placed that there can be no overlapping or falling together of the margins

The pack is fixed in position with an ordinary dressing and the whole limb is then enclosed in a loosely fitting, well-padded, plaster cast, so as to put it absolutely at rest This prevents muscular contracture, slows down the flow of lymph and checks the spread of infection More important still it makes any interference with the wound impossible until the plaster is removed In consequence the chances of secondary infection are notably diminished During the 1914–18 war only 15 per cent of wounds in casualty clearing stations contained streptococci , this figure rose to 90 per cent at base hospitals The repeated dressings then considered necessary were responsible for the difference

The rule of wide-open drainage holds good in almost every case where there is the slightest chance of trouble Naturally there are exceptions With thoracic wounds the pleura must be shut off When the brain is exposed it must be covered So also with the abdominal viscera

The through-and-through stab or bullet wound is the only type that does not require early and efficient excision Excision of such a long and narrow track, which perhaps passes close to vital structures, would indeed be a formidable procedure Fortunately it is rarely necessary, for

experience teaches that the risks of infection are not great If left to their own devices these wounds usually do well[1] Even when a large artery has been damaged and a hæmotoma has formed it is wiser not to interfere at least so long as the blood supply is maintained by the collateral circulation

Eighteen to twenty four hours after wounding there is very little hope of eliminating infection It has already set in and treatment can aim only at providing drainage for the discharges. The same wide incisions as in the earlier cases are required foreign bodies and loose bone are removed but nothing is excised for fear of breaking down the barriers that nature is starting to set up against the invaders

Delayed Primary Suture Healing is by granulation in wounds which are left open and is a tedious business when allowed to take its own course The first plaster may remain in fairly good condition for several weeks if the discharge is not excessive then it must be replaced by another which will probably last longer and so on until healing is complete This regime certainly spares the patient the ordeal of the daily dressing but he remains an invalid for months and months

When penicillin was first introduced it was hoped that it might revolutionise treatment by effecting a *sterilisatio magna* and allowing a contaminated wound to be sutured straightaway These hopes were disappointed But penicillin has made suture after the lapse of seven to ten days a reasonably safe procedure provided that there is no reddening of the skin no pus visible anywhere no pyrexia and the patient can be kept under constant observation At this stage granulations have not yet begun to infiltrate and freeze the structural details and the procedure differs very little from primary suturing

[1] This does not apply to wounds by phosphorous bullets.

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follow the usual lines for a *fulminating cellulitis*—longitudinal incisions to relieve tension and allow discharge to escape Or are the muscles involved? If they are the condition of the patient before operation will probably have given more than a hint of what is happening This deep infection usually sets in with dramatic suddenness twenty four to forty-eight hours after wounding Clinical deterioration is as abrupt as if it were due to a big hæmorrhage The discharge from the wound is thin and sanious but it contains gas bubbles and gas can be demonstrated elsewhere in the limb by means of an X ray On exploration the muscles are found to be bloodless and non-contractile and their colour may range from plum through *various shades of yellow to the dark green of putrescence* If the patient s life is to be saved whole groups of these muscles must be excised but even in this devastating disease the anatomical barriers retain their importance gangrene does not leap lightly from one group of muscles to another So it may be possible to carry out segmental excisions through longitudinal extensions of the wound and so avoid amputation

The effect of penicillin on this form of infection is peculiar It seems that the organisms are killed although the toxin is not neutralised so that the patients sometimes die after surviving a crisis At autopsy a line of demarcation is found separating gangrenous from healthy muscle Nevertheless the case mortality has been halved by use of the drug

Pitfalls in the Diagnosis of Gas Gangrene It is one of the mysteries of infection that a culture taken from a *wound may give a profuse growth of virulent organisms to* which the patient s tissues seem quite immune Even the *B welchii* may multiply itself within the body without becoming pathogenic *Diagnosis* must therefore be made on clinical and not on laboratory grounds

It will usually be carried out after transfer to the base, and always in a fully equipped operating theatre, this being the first occasion on which the dressing is removed A pad is placed over the wound, exactly as before, while the surrounding area is being prepared Then the skin edge is excised, the tissues gently cleansed, and the parts brought together without tension—skin incisions on either side may make this easier Drainage is provided for any dead space that resists obliteration Often it can be dispensed with, and any exudate be aspirated through the tubes used for injecting penicillin into the wound These are better introduced through lateral stabs rather than between the stitches The limb is again immobilised on a plaster slab

The combination of local and parenteral penicillin in adequate doses is often enough to ensure what amounts to healing by first intention, in spite of the initial delay, but this can never be relied on, and the surgeon must be prepared to reopen should there be any evidence of pocketing Fortunately this is seldom required As many as 90 per cent of flesh wounds, treated along these lines during the later stages of the second world war, were soundly healed at the end of ten days

Supposing that secondary suture is undesirable for one reason or another, or has been attempted without success, the patient may still escape a wearisome illness if the process of granulation is cut short by early recourse to grafting The aim in all these cases should be to get *skin cover as soon as possible,* whatever reconstructive operations may be needed later on

Gas Gangrene Gas gangrene may be present, in which case an important distinction is to be made Is it a gas cellulitis, perhaps with extensive involvement of the subcutaneous layers and discoloration of the skin, but no deeper implications? If it is, surgical procedure must

CHAPTER XII

AMPUTATION

When to Amputate A surgeon must come to many graver decisions than when and where to amputate but none with more immediate or dramatic consequences for his patient Especially is this so in the accident case A man who goes out to work in the morning sound and in one piece and finds himself by evening without an arm or leg suffers a terrible loss for which he is totally unprepared It is not to be wondered at if he often goes through the remainder of his life with an idea at the back of his head that perhaps after all the limb might have been saved Sometimes the idea does not remain at the back of his head

It is wise therefore to have a second opinion before amputating and to have it in such a formal fashion as to leave no room for misunderstanding A sentence or two and a signature on the history sheet will leave no room for doubt in anyone s mind

This is all the more important nowadays because the achievements of reconstructive surgery have greatly reduced the indications for amputation Almost any limb can be restored to usefulness provided it has sufficient blood supply to keep it alive. The field for emergency amputation is therefore limited to cases in which —

(1) Gangrene is inevitable.
(2) Destruction is devastating
(3) Fulminating infection threatens life

Few indications in surgery can be laid down as absolute and these like all the rest are influenced by circumstances

Surgical emphysema has been diagnosed as gas gangrene, and its behaviour is often so unpredictable that there may be some excuse for the mistake I have found subcutaneous crepitation round the umbilicus of a girl who had sustained no worse injury than the extraction of a tooth The ways in which air can find its way into parts of the body where it has no business to be are too numerous to set down It is sufficient to mention here that it is quite commonly found in the neighbourhood of a fracture which is compound through a puncture Familiarity with this fact may on occasion save a lot of heartburning

Secondary Suture There is a sharp distinction between secondary suture and delayed primary suture The latter, as its name implies, differs little from primary suture , it is merely held up for a few days to make sure that infection is not developing The former is carried out when infection has done its worst and is subsiding

Nevertheless, secondary suture should not be unduly postponed, or underlying fibrosis will resist all attempts at infolding Three weeks is about the optimum By then the area should be finely granular with little tendency to bleed, and giving off no more than a thin discharge

It may be possible to approximate the skin edges by deep sutures without any undercutting So much the better if it is A lot of bleeding will be avoided If it is necessary to undercut a hot pack held in place for some minutes will staunch the oozing The aim should be approximation , apposition is too much to hope for Lateral incisions will relieve excessive tension, and a well-made corset in abdominal cases will take some of the strain off the stitches If the first repair by this method is not a complete success it can always be repeated But there are cases, especially where there has been loss of skin from the start, in which it is waste of time to defer grafting

repairs are being carried out may easily spell pneumonia and death for anyone who is over sixty

No matter what the age a leg can be removed with much less hesitation than an arm the resulting disability being incomparably less and the prosthesis much more satisfactory At best an artificial arm is little use to the owner Even when he has fairly good control over it he is still forced to rely on a series of attachable appliances for eating and drinking telephoning typing etc *no mechanical device can possibly replace the hand*

Where to Amputate. A stump must not be so long as to interfere with the joint in the prosthesis or to outstrip its own blood supply On the other hand it must not be so short as to slip out of the socket or be under insufficient muscular control It is a basic principle of amputation that the insertion of the main muscles should be preserved

Army surgeons were given the following instructions about amputation levels —

Arm Measured from tip of acromion
Optimum 8 in
Minimum 5 in.

Forearm Measured from the tip of the olecranon
Optimum 7 in
Minimum 3 in

Thigh Measured from the top of the trochanter
Optimum 10 in
Minimum 5 in

Leg Measured from the knee joint
Optimum 5½ in
Minimum 3 in

Allowance for the size of the patient is of course permissible In a tall man the measurement for leg amputation may be increased to 12 inches in a small woman decreased to 8 inches

Conservatism is not so important in an elderly patient An old man will not miss a leg nearly as much as a younger one And he can sit out in a chair the day after it is taken off This is very important for him A long spell in bed while sepsis is subsiding, bones are uniting, and

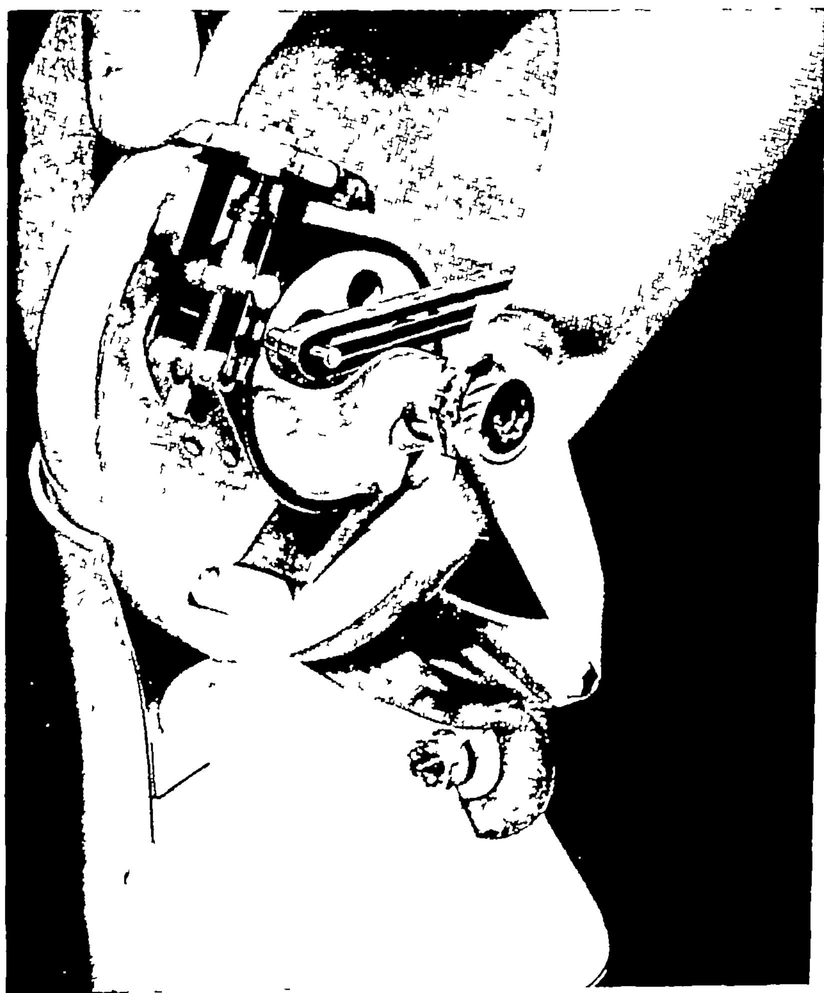


FIG 107 To show the joint in an artificial leg which must be allowed for in deciding the level of amputation This photograph illustrates the original Desoutter design of wheel control, which is now being manufactured by Vokes Ernst Scientific Surgical Appliances

old as the art of war and as subject to periods of obsolescence No wonder it is hung round with tradition some of which dies hard Most surgery books give cryptic instructions about measurement of the flaps with the implication that they will almost certainly shrink There are no grounds for this fear Flaps do not shrink but may easily slough if they are cut too long They should be cut to cover the stump with a little to spare the surgeon s finger and thumb make an excellent caliper to

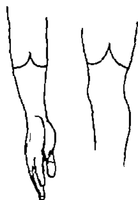


FIG. 109. Antero-posterior flaps for amputation of arm and leg



FIG. 110. A racket incision for amputation at the shoulder



Fig. 111 A racket incision for amputation at the hip.

measure its girth At the finish any tailoring that is necessary to give a snug fit can be done with a pair of scissors

What is the best type of flap? Here again there is no need for elaboration Antero-posterior flaps meet most requirements (Fig 109) and never slough from lack of blood supply The old objection to a terminal scar is not valid except with fingers and toes since limb stumps are not end bearing but it is better to make the anterior flap slightly longer than the posterior so that the suture line does not lie directly over the bone A racket incision

It goes without saying that a below-the-elbow or knee amputation gives better control than one above The minimal measurements given here *represent the least length of stump which is capable of controlling a prosthesis* But at the shoulder it is worth preserving less for cosmetic reasons, and also at the hip, in order to leave a convexity and prevent falling in of the tissues At elbow or knee, on the other hand, a stump of less than the minimal length becomes flexed and interferes with the fitting of an artificial limb

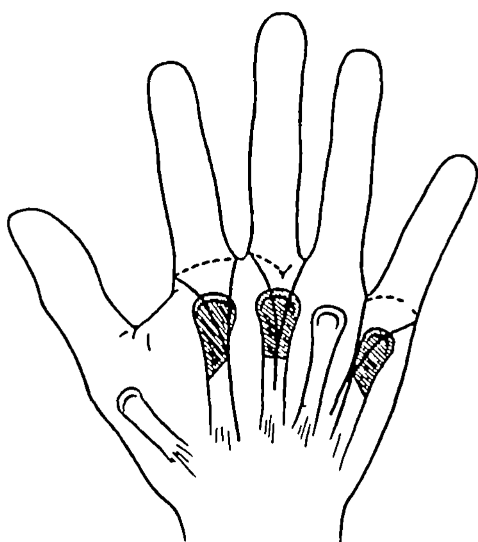


FIG 108 Incisions and levels of amputation for the fingers Dorsal view

In amputating for arterial disease it is usually safer to go above than below the knee Nowadays, however, the oscillometer and the electric thermometer give such accurate information about the extent of ischemia that the surgeon is often in a position to assess a case on its own merits

An emergency amputation is usually performed so as to save as much tissue as possible If the bone is fractured there is no need to divide it higher up Flaps should be fashioned wherever they can be found, because it is important to preserve skin Re-amputation at a later date will probably be required, when the procedure can be carried out deliberately, and with proper attention to the resulting function

Technique of Amputation. The art of amputating is as

(*c*) It used to be the custom to raise a cuff of periosteum before sawing through the bone so that this would come together over the exposed end Nowadays it is considered sufficient protection against aberrant ossification to protect the muscle from dust with a pack while the saw is in action In the leg the anterior edge of the tibia should be bevelled off and the fibula cut back for one inch

(*d*) Formerly too special precautions were taken over the main nerves. They were pulled down crushed and tied off high up This was done in the hope of preventing the formation of a neuroma It always failed in its object Nothing will prevent a neuroma from forming on the end of a cut nerve But the neuroma will not give trouble if it does not become attached to the amputation stump so there is still a case for high division If the nerve is a big one an injection of novocaine into its trunk will diminish the shock of the procedure by blocking conduction

(*e*) Tendons are cut back to prevent them from forming undesirable attachments Efforts to restore some degree of function by re-attaching tendons either to bone or to each other (as in the fingers) have never met with much success and have often done more harm than good

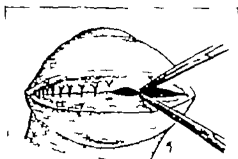


Fig 113. Suturing the fascia (By courtesy of Messrs Butterworth British Surgical Practice)

(*f*) Vessels require a double ligature artery and vein separately because a common ligature might cut through and establish a communication between the two In cases of gangrene however artery and vein are often bound together by an inflammatory reaction and the

is still used for amputation at the knuckle, and sometimes at the shoulder and hip

The steps of the operation are as follows —

(*a*) Skin, subcutaneous fat and deep fascia are raised together In some parts of the body the deep fascia thickens into an aponeurosis, as in the ilio-tibial band, or blends with the periosteum as over the shin Whatever

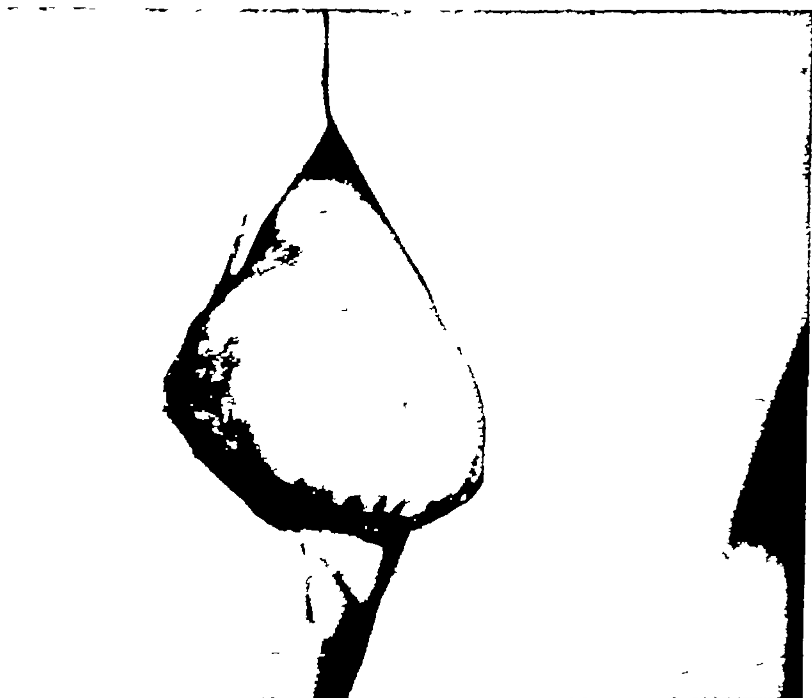


FIG 112 The scar of a thigh amputation should lie slightly to the back

its arrangement may be it gives a good hold for suturing, and should be made use of, even if this necessitates elevating the periosteum a little from its bed

(*b*) Muscle is severed Although it retracts the aponeurotic suture will bring it together again at the finish, and so help to obliterate dead space and prevent the skin from becoming adherent to bone

thumb should be saved *Functionally it is half the hand* In ancient times the victors in a sea battle used to cut off their opponents thumbs in order to incapacitate them Conservatism is the rule too with the fingers though with some qualification The tendons are inserted into the bases of the second and third phalanges and amputation proximal to these is likely to leave the patient no better off than if the whole finger were taken away There is however something to be said for it in the case of the third and fourth fingers—the stump maintains the alignment of the fingers that are left which otherwise tend to fall together From a cosmetic point of view amputation at the knuckle is always inclined to leave an ugly hand in the first and fifth fingers because of the prominence of the knuckle in the third and fourth because of the wide gap remaining The difficulty can be got over by excising the knuckle (Fig 108) but this sacrifice weakens the grip and must not be imposed on a working man Occupation is a thing that must always be given full consideration in dealing with such problems

With finger amputations more than any others it is essential to have good healthy skin cover preferably deriving from the palmar aspect where sensation is better developed. This is achieved by using a palmar flap which has the additional advantage of carrying the scar to the back where it is away from pressure At the meta carpo-phalangeal joints a racket incision with the handle posteriorly gives good results (Fig 108) The digital nerves and tendons should always be cut back

Amputation and Infection. Sepsis is a common enough complication of amputation though it sometimes comes as a surprise to the surgeon who argues that since he has been at great pains to isolate the sterile field there should not be a higher incidence of infection than in any other operation With an accident case he argues if the

attempt to separate them may mean unjustifiable delay In amputations at shoulder or hip a tourniquet cannot be used with any satisfaction, and it may be advisable to start the operation by ligating the subclavian or external iliac arteries in continuity The racket incision was designed with this object in view Having secured the main vessels all others must be dealt with methodically The little artery accompanying the sciatic nerve often gives trouble it should not be ligated unless it can be separated from the nerve

(*g*) The flaps are anchored to each other by a few interrupted stitches, and if there is any redundancy it is carefully trimmed away If not corrected, puckering, inversion, etc , will lead to intertrigo later on When the fit seems satisfactory the fascia is carefully brought together with interrupted sutures before stitching the skin When possible it is better to avoid drainage quite often even this precaution does not prevent hæmatoma formation (see Chapter VII)

Healing should be by first intention, and when it is complete the wound should be quite mobile on the deep tissues, *i e* , the bone In other words, the result, so far as the wound is concerned, ought to compare with the results of any other type of operation

The instrument maker likes a conical stump of the right length, with the skin freely movable over its extremity, so that it is not dragged upon by the in and out movement in the socket Immediately the stitches have been removed, therefore, the stump should be firmly bandaged from below upwards in order to mould it into the desired shape If necessary a temporary pylon may be used to encourage this process

The Hand From what has been said about the hand it is clear that no effort should be spared to preserve it in whole or in part At all costs as much as possible of the

procedure is that there is nothing to prevent the muscles from retracting carrying with them the other coverings of the limb and leaving bare bone to protrude into the dressings Below the site of election this is unfortunate At the site of election it is *disastrous because the patient* is left with a conical stump which can only be improved by re amputation the new stump being inevitably too short to control a prosthesis If therefore it is necessary to amputate by the guillotine method some form of exten sion should always be set up to control the soft parts after operation

Late amputation of an infected stump or extremity may still be hazardous if proper precautions are not taken against a flare up Every effort should be made to reduce sepsis to a minimum before operation in such a case At the time of operation the infected area should be rigorously excluded from the sterile field so that there is not the *slightest possibility of conveying infection directly from* one to the other This does not get over the difficulty of the lymphatics which may spill their effluent into the wound when they are cut across So adequate drainage is necessary to provide against the worst should it occur

In all these cases antibiotics must be given pre and post-operatively

Complications and Sequelæ of Amputation (1) Hæmorrhage It has been said that if it takes five minutes to remove a limb another twenty five should be *occupied in dealing with the bleeding* Certainly the surgeon should take very great care of the main vessels and after the tourniquet has been taken off spend a con siderable time picking up the smaller ones the most troublesome of these will be found on the cut surface of muscle which has a great tendency to ooze unless hæmostasis is very thorough When there is a possibility of secondary hæmorrhage as from a guillotined stump it is

mangled foot is well wrapped up, the leg is thoroughly prepared, and the amputation is carried out at the site of election, a hand's breadth below the knee, there should be no reason for concern about the wound

It is true that the ordinary precautions should prevent trouble in a case of this kind when there has been no great delay between the time the injury was inflicted and the time the patient was put on the table But if more than six to eight hours have elapsed organisms will have begun to spread along the lymphatics in a proximal direction and will have probably reached as far or further than the

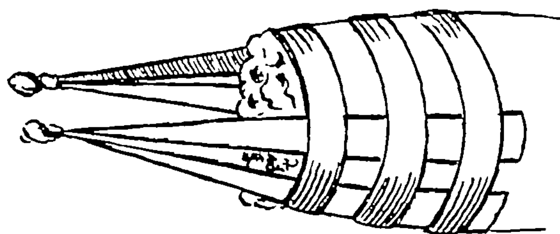


FIG 114 An extension on an unsutured amputation stump, preserving cover for the stump is the secret of success

site of election Amputation followed by immediate closure under such circumstances is a risky business The only safe thing to do is to proceed on lines analogous to those given in the chapter on wound toilet The skin flaps can be loosely stitched over a pad of vaseline gauze, and left for a day or two before they are brought together by delayed suture, or alternatively, they can be held apart by an extension apparatus until the danger is over In still later cases, when infection is established and perhaps menacing life, similar methods must be employed But there will sometimes be patients so ill that operating time must be cut to an absolute minimum, and drainage must be total Here the guillotine operation comes into its own, and the surgeon does his work with a sweep of the knife and a cut of the saw The great disadvantage of this

Refrigeration Anæsthesia In many amputation cases the patient is in very poor condition to withstand a major operation He may be an arteriosclerotic with a failing heart a diabetic with a high blood sugar or toxic from the absorption of the products of moist gangrene A general anæsthetic on top of his other disabilities may be just enough to tip the balance against him

It has been found that if the limb is completely surrounded by crushed ice for two or three hours before operation sensation is abolished and there is no need for any further anæsthesia If a tourniquet is used it should not be applied until the ice has had an hour or so to act The ice is left until the patient reaches the theatre

Refrigeration as might be expected checks bacterial activity and reduces metabolism to a minimum It can be used to relieve pain and abolish the toxæmia from a gangrenous limb in the days preceding operation while the patient s general condition is being built up to fit him for the ordeal The great drawback to this form of treatment is the difficulty of keeping the sheets and blankets dry but it can usually be overcome by packing the ice into mackintosh bags or some other form of watertight container which drains away towards the foot of the bed

not a bad plan to disperse the blood stream by ligaturing the main vessel in continuity higher up

(2) Sepsis should not arise in clean cases, but it not uncommonly does, mainly as a result of hæmatoma formation

(3) The commonest complication affecting bone is the development of osseous extensions of one sort or other, but since most of these " spurs " cause no trouble perhaps it is wrong to describe them as complications Infection involving bone is a much more serious consideration, and may result in the formation of a ring sequestrum Any disparity between length of shaft and cover for it is likely to lead to bone protrusion, and this is another way in which osteomyelitis may arise The sequence is not uncommon during the years of growth In the adult a similar disparity produces a terminal ulceration of the stump, which can only be cured by re-amputation at a higher level

(4) Adherent Scar This complication can be prevented by bringing fascia and fat together over the end of the bone A patient may be fairly comfortable in spite of having an adherent scar, but it should be remembered that at every step he takes there is an in and out movement of the stump in the socket and if the skin cover can move freely on the deeper parts this piston action is much less likely to cause trouble than if it cannot

(5) Puckering and intertrigo are due to redundant flaps Ulceration and eczema, most often seen after amputation in the upper third of the leg, are due to inadequate flaps or flaps with poor blood supply

(6) Adherent Neuroma (see above) Apparently some pain following amputation is caused by interference with the sympathetic supply to the limb Causalgia is of this nature How exactly it is produced or how it can be avoided is not clear

the right course to take Anything in the way of exploration or leaving suture material behind is entirely wrong under such circumstances The repair should be absolutely ignored for the time being and attention concentrated on measures to combat infection When the wound toilet is complete the skin is closed and nothing further is done until all danger of a flare up is past

Time for the Second Operation If healing follows by first intention it may be safe to tackle the next stage within a fortnight or less On the other hand if infection

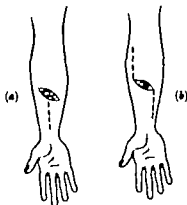


FIG 115 If it is necessary to extend a transverse laceration this should not be done so as to give a T-shaped wound (a) is wrong, (b) is much better

develops further interference may have to be postponed indefinitely It is not enough to wait until discharge ceases The tissues must be quite soft and free from all tenderness before it is safe to do the second operation If this takes more than a month direct tendon suture may be impossible because of muscle shortening in which case grafting will be required

The Exposure for Tendon Suture Since identification of tendons at any stage is seldom an easy business it is not a bad plan to operate under some form of block anæsthesia so that the patient can help in the search by moving or trying to move any particular digit But whether the

CHAPTER XIII

TENDONS

TENDONS with sheaths, *e g* , the flexors of the wrist and ankle, and tendons without, *e g* , the corresponding extensors, behave differently from a surgical point of view The former when cut retract within their sheath, which prevents them from forming adhesions , the latter retract much less, and may even re-unite Neither are well equipped to deal with infection, but of the two the sheathed are more handicapped, a sheath being an invitation to the spread of suppuration and a check to swelling That is why infected flexor tendons commonly slough

Primary and Secondary Suture. The casualty department is no place for tendon surgery All the refinements of the main operating theatre are essential if good results are to be obtained, and even with these there can be no certainty about the issue So pessimistic are some surgeons over these cases that they refuse ever to perform a primary suture of a cut tendon This is an extreme view The chances are that immediate suture of an extensor tendon in a clean wound, or in one that can be cleaned by a standard surgical toilet carried out within the prescribed limits of time, will prove successful Flexors tendons, with their tendency to retract and to harbour infection, are less amenable, but, unless circumstances are adverse, the challenge should be accepted in the palm and certainly at the wrist, where cut ends are very apt to fuse if they are left When, however, the state of the wound is open to doubt, and still more when there is crushing, bony injury, or skin destruction, there can be no question about

already be an adherent scar and perhaps an extensive one After severe sepsis all the tissues of the part including the skin may be blended into a conglomerate mass so that the task of restoring anything resembling the original architecture seems quite hopeless If it is attempted the first step should always be to provide a new and mobile

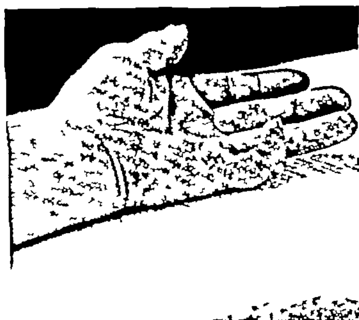


FIG 117 Contracture following an anterior incision on a finger

skin covering And whatever the condition beneath the approach should invariably be by a flap from one or other side of the affected area

Display of the damaged tendons may be extremely difficult in these cases so the rule of *dissecting from the normal towards the abnormal should be closely observed* above or below the frozen landmarks of the lesion it may be comparatively simple to find planes of cleavage The aim should be to clear the field of every particle of fibrous tissue leaving only the normal structures in a bed of

anæsthetic used is local or general, a tourniquet should never be dispensed with

In a primary suture it may be possible to identify the cut ends in the original wound, the distal by flexing or extending a digit, the proximal by milking or squeezing the synovial shrouds But not uncommonly wider exposure is necessary before this is practicable The obvious step then is to extend the incision along the course of the tendon until its retracted end is revealed But if

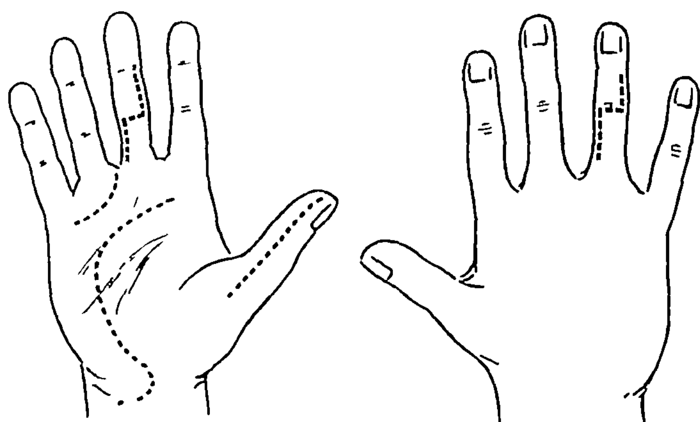


Fig 116 *Incisions for the hands and fingers*

this is done the healing scar will lie directly on top of the tendon and may become adherent to it in its whole length Any extension must therefore be on the zig-zag principle (Fig 115) All creases must be treated with the greatest respect Incisions crossing the palmar flexures are likely to contract, mid-line longitudinal incisions on the fingers are certain to Sometimes it may be possible to identify a retracted tendon end through a separate incision higher up, pass a suture through it, thread this on a probe, and slip the probe down the thecal tunnel to where the other end has been exposed below Skin incision is thus reduced to a minimum

Secondary Suture In secondary suturing there may

The twin bugbears of tendon suture are —

Cutting out
Adhesions

The longitudinal arrangement of the fibres plus the strength of the pull transmitted through them makes cutting out almost certain with a flexor tendon unless special precautions are taken to prevent it happening And this means something more than the use of an unabsorbable suture for this will cut out as readily as any other when reactionary softening sets in The only real safeguard lies in some form of splicing Suitable methods are illustrated in the diagrams



FIG. 119. If tendons of unequal size are united the larger end will sprout and form adhesions.

Whatever technique is used nothing must be done which might encourage the formation of adhesions Frayed ends should be carefully trimmed matching should be accurate And all knots should be buried with their ends cut short so that there is no thickening round the union

Adhesions between a tendon and its sheath can be broken down if movement is started early (three weeks for a flexor tendon) As much cannot be said for adhesions to surrounding structures especially when they are as intimately related to the tendon as the digital theca or the annular ligament. Where the relations are less cramped as between tendon and skin a layer of fat can sometimes be interposed between the two to act as an insulator It is particularly useful if there is an incision

healthy fat and areola If this is not done thoroughly recurrent fibrosis can be counted on to reproduce the original pathological condition Fibrous tissue breeds fibrous tissue [1]

To get a good functional result every tendon must be repaired, or at least none may be left tethered If repair is not practicable a tendon should be excised or transplanted into an adjacent one, for if it remains bound down it will hamper the others arising from the same muscle group like a lame horse in a four-in-hand

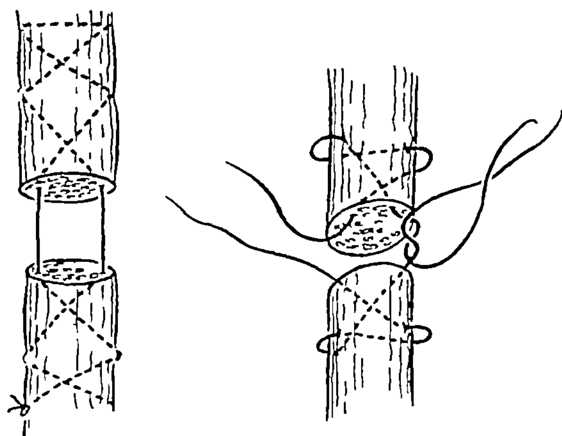


FIG 118 (*a*) This stitch is of one length, but two needles are used The proximal half is inserted first, and its slack taken up Then the distal half is inserted, and its slack taken up so as to approximate the two ends (*b*) This stitch also is inserted with two needles, it is suitable for a primary suture

The Suturing A tendon should be picked up with a tissue forceps that gives a good grip, it ought not to be crushed by a Spencer-Wells or frayed by an instrument that allows it to slip

Linen thread, fine braided silk, or steel wire, are the best materials for suturing Catgut is irritant, bulky and largely absorbed before the time when gentle movements should be started

[1] This applies everywhere—in a Dupuytren's contracture, a torticollis, or a fistulous perineum

unless a special technique is employed This involves sacrifice of the sublimis tendon and the use of a suture which provokes the absolute minimum of reaction is completely buried at the site of the lesion and can be removed after it has done its work Bunnel uses No 40 gauge stainless steel wire on an atraumatic needle and leaves it for three weeks

Failing this it is worth trying a free graft obtained from palmaris longus or one of the extensors of the toes The finger is opened through a lateral incision in front of the digital nerve and both tendons excised leaving only the stump of the profundus which is split The retracted profundus is next exposed through a palmar incision and *fixed to the graft from the other end of which a suture is* threaded into the finger on a probe The graft is then delivered and united to the split profundus by a wire passing through the phalanx and tied over a button

Tendon Transplantation and Fixation Probably the most convenient method of transplanting one tendon into another is to make a slit in the recipient tendon pass the other through and bury its end in a small incision in the recipient just below the slit so that it does not throw off adhesions To fix a tendon to bone pass it through a drill hole in the bone and suture it back to itself using a similar technique

Tenotomy A tendon without a sheath can be cut subcutaneously but the results are often unsatisfactory and the procedure has been largely given up except for the extensors of the toes An open operation is much more certain and does not carry the same risk of doing too little or too much The tendon is slit longitudinally with a small transverse incision at either end This permits exactly the amount of slide required to achieve the desired effect which can then be maintained by suturing

The Dressing At the end of any operation on tendons

in the neighbourhood which threatens to become adherent

In the Hand A flexor tendon can be sutured at the wrist or in the palm with good prospects of success Not so in the finger, at least proximal to the insertion of sublimis Here the sheath is so narrow that it is practically impossible to avoid making the union too bulky,

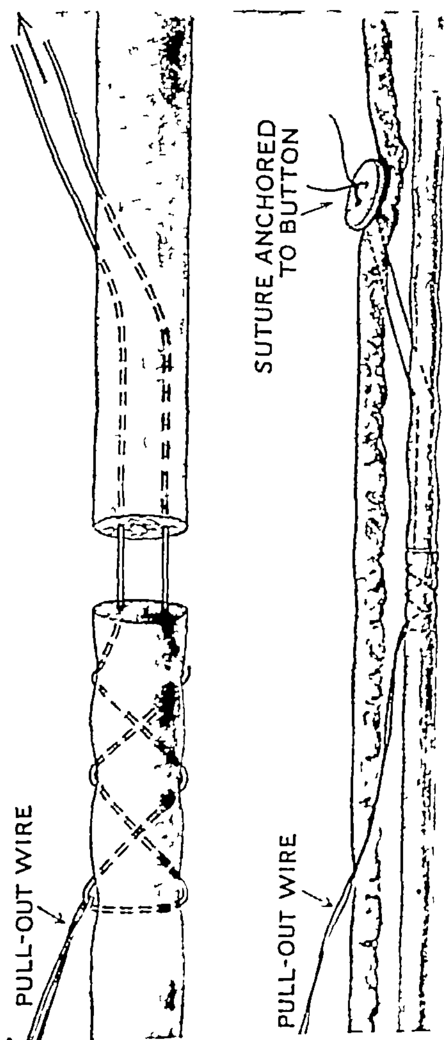
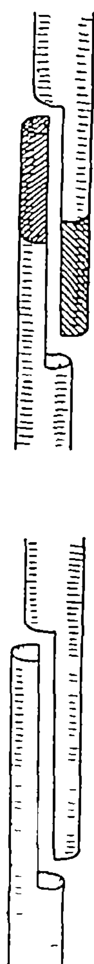


Fig 119A The removable suture for tendons From "*Textbook of Operative Surgery*," by L L Farquharson, E & S Livingstone, Ltd



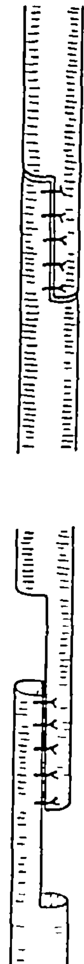


Fig 119B Tendon lengthening and shortening From "*Textbook of Operative Surgery*," by E L Farquharson, E & S Livingstone Ltd

CHAPTER XIV

NERVES

It is doubtful whether it is ever justifiable to do more than anchor the ends of a divided nerve together at the time of the accident Even a straightforward suture may set up intra neural infection and any more elaborate interference may spread trouble far and wide The results appear to be better if the actual repair is left until later when all chance of sepsis is past If the wound becomes infected it may take a long while to heal and it will be still longer before the part is in a really healthy condition The delay is bad for the nerve and bad for the limb but is unavoidable though everything should be done to shorten it as much as possible Meanwhile all joints should be put through a full range of movement at least once daily and the muscles kept in trim by electrical stimulation When the second stage has to be postponed beyond a year or eighteen months the prognosis is poor

In the circumstances the definitive operation is likely to be a difficult one A tourniquet should be used and the usual rules for incisions observed (see chapter on tendon suture) The nerve in these cases is often adherent to the skin at the level of the injury It should therefore be exposed above and below where it retains its anatomical relations Dissection—always along the course of the structure in danger never across it—then reveals the lesion Special care is needed when working in a retrograde direction to avoid damaging diverging branches

The bulbous ends of the nerve must now be amputated This is done by taking serial sections off it with a sharp scalpel until a place is reached at which the funicular pattern is normal and there is no excess of fibrous tissue

the wound should be absolutely dry, and even so a firm pressure dressing should be applied to discourage reactionary oozing If a hæmotoma develops fibrosis is certain to follow As a final safeguard against this, and in order to prevent any strain on the repair, the part should be completely immobilised, preferably in plaster of Paris Elevation for 24 to 48 hours after operation relieves congestion and lessens pain

Union of a cut tendon takes four weeks, but some surgeons permit active movements very much sooner than this

obstacle to recovery Fine braided silk preferably on an eyeless needle is far and away better than any form of catgut for the suturing

Anything in the way of tension must be completely relieved otherwise the operation is likely to be a failure As has been said wide mobilisation is the most important means of securing this but some help may be had from liberating or even sacrificing known branches and transposition is possible in certain situations *e g* the ulnar nerve from the back to the front of the elbow Also the position of the limb can be altered. Flexion at wrist elbow or knee may help to overcome separation but it does not do to trust too much to this method Whatever present advantage it confers the joint must eventually be extended and this extension may cause enough intra neural fibrosis to establish a fresh block to conduction At the wrist 45 degrees of flexion is given as the upper limit for safety at elbow and knee 90 degrees. Whatever the ease or difficulty of union *a nerve suture should be left until all other procedures (tendon sutures etc) are complete* Then the wound can be closed and the limb immobilised in a postion of relaxation without further disturbance The craze for isolating the suture line with any form of tube natural or manufactured is dead. The best covering is fat and if this is not available in the immediate neigh bourhood it can usually be swung over in the form of a pedicle graft from somewhere close at hand Even if it is necessary to use a free graft there is always a good chance that it will survive

Prognosis With a gap of more than 7 cms (5 cms for the external popliteal) direct suture is seldom followed by restoration of function Nerve grafting in various forms has met with some success in these cases The other factor that plays a big part in prognosis is the level of the lesion A high lesion means that the regenerating fibres

The resection inevitably adds considerably to whatever shortening may have been caused by the original injury. Chief reliance in compensating for this must be placed on extensive mobilisation, pursued if necessary from forearm to arm, or from leg to thigh. Full exposure is absolutely necessary, and it is wise to start the operation with an incision which traverses the whole length of the part. There need be no fear of cutting off the blood supply of the nerve by separating it from its bed because most of the vessels in its substance run longitudinally.

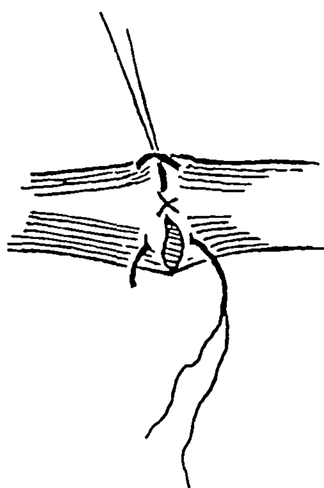


FIG. 120. A nerve suture

Four things are to be avoided in suturing:—

(1) Crowding
(2) Rotation
(3) Cutting out
(4) Tension

It is easy to prevent crowding of the ends. Rotation can be guarded against by attention to the natural lie of the nerve, its shape and striation, and the funicular pattern of its cut surface. If these are taken into account it ought to be possible to insert a couple of stay sutures to maintain correct alignment while the permanent suturing is being completed. Accuracy is important, because the slightest rotation may result in motor fibres being diverted along sensory paths and vice versa with inevitable frustration of function.

No suture, stay or permanent, should go deeper than the sheath (which is agreeably thickened at the time of a secondary operation).

Only the most delicate dissecting forceps may be used, and these again only on the sheath. The slightest trauma will produce intra-neural fibrosis, which is the main

surgeon to come to a conclusion and so will the response to electrical stimulation of the exposed nerve Some kind of stimulator should always be available in the theatre when this type of case is being operated on If doubt persists it is quite justifiable to incise the neuroma longitudinally and examine its texture

Preventing Regeneration Oddly enough when the surgeon is concerned not to restore continuity but to abolish it for good he not infrequently fails in his object This is mainly true of sympathectomy and the reappearance of function may have to do with opening of new pathways rather than regeneration Whatever the explanation it is wise to make a wide excision and sometimes to put a silver clip on the cut ends of the chain or anchor them well away from their ordinary position

have a long way to travel and are, in consequence, less likely to reach their destination An injury to the brachial plexus is not one that can be regarded with any optimism by the surgeon who attempts to repair it

A Check on the Result. Since disruption of a sutured nerve usually goes unrecognised until it is too late to hope for any success from a fresh attempt at repair, some surgeons take steps to ensure that they get early information of what has happened By attaching two tiny metal clips or stitches of steel wire to the epineurium of the nerve on either side of the union and X-raying at the end of a month, it is possible to tell at once whether separation has occurred or not

A similar principle has been used to keep check on other types of suturing, *e g* , in herniorraphy

Lesions in Continuity A closed injury to a nerve is seldom a complete one, even though the resulting paralysis may appear to be so The reverse is true of an open injury, or one that has been open in the past It follows, therefore, that delay in operation is justifiable and often advisable in one case, rarely in the other, when early repair gives the best hope of a successful issue If motor loss is not recovered within eighteen months it has probably gone for good , any further delay in restoring continuity is, therefore, unjustifiable Sensory loss may be regained in some degree as long as five years after an accident, which gives the surgeon a much wider latitude in dealing with a nerve like the median, whose sensory function is much more important than its motor

At exploration it is sometimes found that anatomical continuity of a nerve has not been lost, the ends being united by scar tissue, by a combination of scar tissue and nervous tissue, or by some kind of neuroma The decision whether to resect and suture or to leave well alone is then a delicate one Clinical findings beforehand will help the

Heparin originally prepared from liver has been successfully synthesised In 1/1 000 solution in saline it takes the place of the 3 8 per cent sodium citrate which was formerly employed to irrigate a wound while a vessel was being sutured It may also be given intravenously either intermittently or by continuous drip in order to lengthen the coagulation time of the blood generally Its effect is evanescent so of the two methods the drip is preferable. For fear of actual hæmorrhage it is wise not to start administration until four hours after the operation Dosage is different with different preparations and should be checked by estimation of the coagulation time Twenty four thousand Canadian units in twenty four hours will treble it in most cases and this is about the limit of safety Simultaneously dindevan can be given by mouth It takes twenty four hours or longer to act but may then replace heparin. The customary dose is 100 mgms twice daily for the first twenty four hours and 50 mgms twice daily after that under laboratory control Protamine sulphate 10 mls of 1 per cent antagonises heparin and Vitamin K_1 has a similar effect with dindevan

A solution of papaverine applied externally to a vessel at the time of operation discourages distal spasm which might mar the result

Technique. Anti-coagulant drugs are a considerable help in vascular surgery but some surgeons because of the risk of hæmorrhage only use them locally and depend on the accuracy of their technique to prevent thrombosis. So long as the blood has access to tissues in which hæmoplastin has been liberated by surgical or other trauma clotting is inevitable All depends then on restoring the continuity of the intima which is the insulating coat and doing it in such a way as not to damage its gossamer structure Delicate instruments and the finest of paraffined silk are essential for this kind of work.

CHAPTER XV

VESSELS

Anatomy and Physiology The student fresh from the dissecting room and the physiological laboratory expects to be able to recognise a major artery by its bright pink colour and vigorous pulsation Actually, its colour is white (with perhaps a bluish tinge), and it may be as lifeless as a piece of string and not much thicker if it has been at all traumatised Sometimes the whole vascular tree of a limb is thrown into this kind of spasm, which the French call " *stupeur arterielle* "

Case Note A house surgeon was left to deal with a case of varicose veins Instead of tying off the internal saphenous vein he tied off the common femoral artery

A similar blunder has been made more than once and is by no means as incredible as it sounds Anyone who finds it difficult to imagine how such mistakes can occur will find enlightenment if he ever sees the brachial artery and the median nerve exposed by operation in the middle of the arm (the relationship of these structures to each other at this level is not constant)

For the most part a vessel operated on is diseased, and in consequence its structure must be greatly altered An atheromatous artery has been known to give way while being gently handled , it is quite usual to find artery and vein glued to each other by inflammatory reaction when one or other is thrombosed

Anti-thrombotics The normal clotting time of about five minutes can be greatly prolonged by two substances, recently discovered, heparin and dicoumarin

in the laboratory rather than on one of his patients After a little practice he may conclude that the difficulties appear more formidable than they really are

For exploration or anastomosis the steps are the same whether artery or vein is being dealt with though naturally the latter is easier to manage because of the lower pressure within its lumen In neither case is hæmorrhage

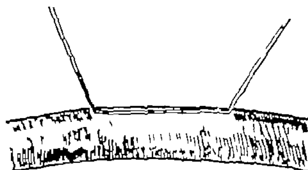


FIG 124. Stay sutures inserted before incision of a vessel.



FIG 125 To close an incision in a vessel interrupted mattress sutures are inserted so as to *evert* the edges.

nearly such an obstacle to progress as might be imagined it is in fact more of a bugbear than a real danger During the operation it can be easily and effectively controlled in a number of ways Rubber covered clamps temporary ligatures tied over bits of pressure tubing traction on tapes threaded under the vessel above and below aluminium clips all answer the purpose satisfactorily And when the operation is finished it is surprising how completely suturing stops bleeding even from a main artery

Two operations will be described—exploration of a vessel (as for embolectomy), and end-to-end anastomosis of a divided vessel Embolectomy is attempted fairly

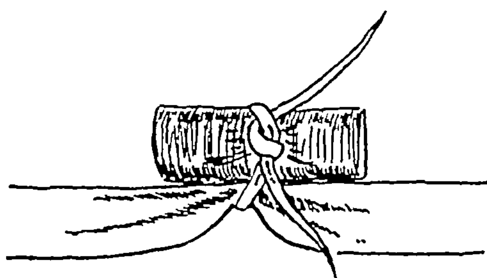


FIG 121 Hæmorrhage can be controlled by tying a piece of tape round some rubber tubing laid alongside the vessel

commonly in recent years and is not a complicated procedure The opportunities of doing an end-to-end suturing after accidental division of a vessel are few and far between, but short circuiting of vessels by deliberate and carefully planned anastomosis is now being carried

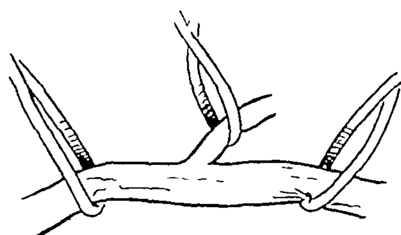


FIG 122 Hæmorrhage controlled by rubber slings

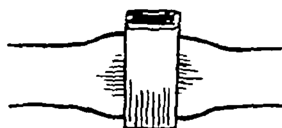


FIG 123 Aluminium clip on a vessel used as a trial ligature

out in some clinics for certain forms of vascular obstruction This type of surgery is still in its infancy, but is undoubtedly entering on a period of expansion such as gastric surgery passed through fifty years ago The surgeon who looks to the future and interests himself in it must learn the technique in the clinics where the experimental work has been done, also he may find it well worth his while to perform his first operations on an animal

account it is never easy to repair An end to-end anastomosis for instance must often be under a good deal of longitudinal tension which is certain to interfere with healing Not only this but suturing is very likely to produce narrowing and that at a point where the intimal lining is broken All these factors predispose to thrombosis but one at least can be minimised by taking great care to avoid puckering

The following technique is accepted (Fig 128)

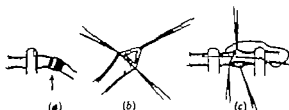


Fig 128 Vascular anastomosis (a) Stripping the adventitia (b) The stay sutures. (c) The suturing.

(1) Cut away excess of adventitia it tends to be redundant

(2) Anchor the two ends together by three guys in such a way as to form an equilateral triangle *with everted edges*

(3) Make the anastomosis with a continuous stitch but anchor it to each guy in turn so that it cannot pucker

(4) Release the controls If there is any bleeding a mattress or two will check it

The Collateral Circulation The collateral circulation is a thing never to be forgotten in vascular surgery There is always a possibility greater in some cases than others that it will open up and provide an alternative route for the blood to travel by But this requires time and anything which will tide the patient over the danger period is worth trying So an anastomosis which is eventually doomed to obliteration may have served its turn if it keeps even a diminished stream of blood flowing for twenty four

Exploration For exploring a vessel, the incision, which should always be longitudinal, is defined by a couple of stay sutures at either end Between these the knife goes cleanly through all coats The interior can then be examined by cautiously releasing the upper or lower control , a soft catheter slipped up and down the lumen with gentle suction applied to its mouth will dislodge any clot that has not already escaped Mattress sutures, carefully introduced so as to *evert the edges*, are used to close the incision (Fig 125)

The present tendency is to reserve this procedure for cases in which an embolus lodges in the aorta, iliac, or femoral vessels Embolism in the upper limb is probably

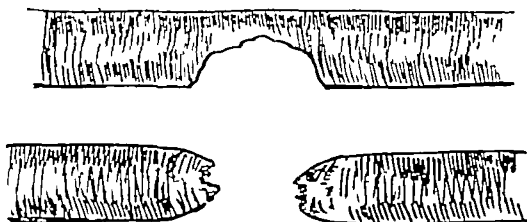


Fig 126 A torn vessel gapes a severed vessel contracts and retracts

better treated conservatively with the help of anti-coagulants

Anastomosis A partial or complete transverse section of an artery is always followed by retraction, and on this

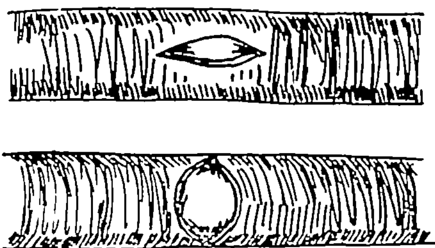


Fig 127 A longitudinal laceration in a vessel retracts a little, but a transverse laceration gapes widely and is often best repaired by completing the division and re anastomosing

Restoring the Lumen Reconstructive surgery is only possible with the larger vessels in which the wider lumen simplifies suturing and the forceful blood stream lessens the likelihood of thrombosis Below the elbow or knee this type of operation is not worth attempting

Various methods have been employed —

(*a*) The ends of the artery can sometimes be united after excising a diseased segment with very satisfactory results

(*b*) After slitting the artery longitudinally it is possible to clear out organised thrombus and thickened intima by developing a plane of cleavage through the media The procedure is known as endarterectomy In spite of the absence of intima these vessels do not always thrombose subsequently

(*c*) Venous grafting A vein from the same subject can be used for replacement after excising the offending segment of artery Naturally the vein must be reversed so that its valves do not interfere with the blood flow

(*d*) Arterial grafting Grafting another artery from the same subject would be ideal Unfortunately there are no arteries of the right calibre to spare in the human body However homologus grafting proves satisfactory in practice The artery is taken with full aseptic precautions from a fresh cadaver and can be preserved for a considerable time It is more convenient to work with and withstands strain better than a vein Nevertheless only the elastic lamina survives

(*e*) The fact that a channel so constituted of inert fibrous tissue remains patent has suggested the possibility of using a prosthesis instead of a graft and plastic material has been employed for this purpose The thought that a man can go about his work with a nylon aorta is indeed a startling one Although a replacement of this kind is an extremely long and arduous undertaking the actual technique of suturing does not depart from standard lines

or forty-eight hours In the same way the Tuffier cannula (Fig 129), which can never hope to fulfil any permanent function, may with the help of anti-coagulants stave off disaster until nature brings her compensatory mechanism into action

It is with this same idea of giving time for collaterals to enlarge that the surgeon is advised not to interfere with penetrating wounds of arteries unless he is forced to

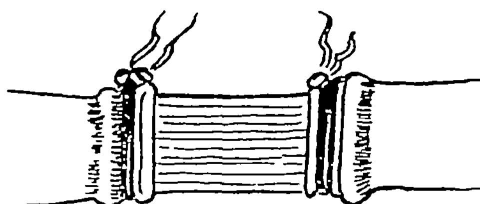


Fig 129 The Tuffier cannula

If the circulation seems to be maintained it is better not to risk destroying collaterals by exposing the main vessel in these cases After all, the injury may only be a partial one and quite a lot of blood may still be finding its way along the lumen to the periphery Circulation is facilitated by keeping the limb below the horizontal, and its metabolic demands will be diminished if its temperature is lower than that of the rest of the body, as it will be if the bed clothes are folded back

Vascular Obstruction As with so many other conditions, the diagnosis of chronic vascular obstruction has now been taken over by the radiologist Clinically, obstruction may be suspected, and its level more or less localised, but accuracy rests with the arteriogram, which shows not only the exact site of the block, but the state of the vessel above and below, on which depends the chances for restoring function The plates are taken as diodone is injected into the main artery This can be done either with or without a small incision over the vessel

that the best treatment for an arterio-venous communication would be to restore the *status quo ante*. But the vessels in these cases have usually undergone deterioration under the unaccustomed strain, and are seldom fit to shoulder their former burden. Certainly the vein should never be preserved, and the artery only when it looks quite healthy. As a rule quadruple ligature and excision proves most satisfactory—excision being necessary, as with ordinary aneurism, because of vessels entering the sacs. Here again excision and grafting may become the treatment of election when the vessels concerned are important ones.

When to Operate on Aneurism. In traumatic aneurism of any kind it is never advisable to operate straightaway unless to save life. There are three strong reasons for this: (1) spontaneous cure is not unknown; (2) delay allows the condition to localise and define itself; (3) and it gives the collateral circulation time to open up. Three to six months is a good interval to allow.

The Role of the Sympathetic. In many cases in which vascular surgery is required the blood supply to the part is diminished and there may even be a danger of gangrene. Interruption of the sympathetic supply to the vessels may improve the prognosis by cutting out the vaso-constrictor impulses and allowing free vaso-dilatation. It may be that the patient is in no fit state to withstand a formal sympathectomy. A novocaine block is then a possible alternative which will add little to the strain of the main operation.

(*f*) Short circuiting A length of vein can be used to unite an artery above and below an obstruction The method has the advantage of not interfering with collaterals

Aneurisms. Aneurisms are of two kinds—fusiform and saccular The fusiform aneurism is a symmetrical dilatation, the sacular a local bulge, sometimes communicating with a relatively healthy vessel by no more than a narrow opening It is obvious that any surgical treatment of the first variety must be obliterative , with some of the latter reconstruction is possible

In earlier days surgeons contented themselves with efforts to promote thrombosis within the aneurism To this end Anel applied a ligature immediately proximal to the dilatation Hunter applied his further away in the belief that this would give a slower and firmer thrombosis

Hunter's method usually succeeds in popliteal aneurism, provided gangrene does not supervene, but in general ligature fails to cure because it leaves out of account the vessels entering the *sac itself* Although pulsation may diminish or disappear for a while after such a procedure, it eventually returns as forcibly as ever If the blood supply is to be entirely cut off one of two plans must be adopted *Either the aneurism must be excised completely, or it must be split open and closed up from within by superimposed layers of silk suturing*

Excision involves a difficult dissection in which important nerves and even the collateral circulation may be endangered Endoaneurismorrhapy, as the obliterative operation is called, is free from these risks, but for some reason has never been very popular in this country

The new grafting operations have been applied to aneurism with lasting success, and there is no doubt that future treatment will follow these lines

Arterio-venous Aneurism At first glance it would seem

Accordingly the dose should be reduced to half the normal and suitably diluted. Probably the safest and most satisfactory way of giving morphine in these cases is intramuscularly; this gives the best chance of satisfactory absorption.

Shock. In burns shock is peculiarly likely to be insidious. A tale is told of a young medical officer who was brought into his own hospital during the war badly burnt. His condition was so good, however, that when he was comfortably installed in bed he sent for the surgeon of his choice and gave him detailed instructions about the kind of treatment he thought would be best for himself. He died while this treatment was being carried out.

Shock is a prime consideration in these cases and should be anticipated and prevented by intravenous therapy when the burn covers 15 per cent of the body surface in an adult or 10 per cent in a child or considerably less than this if the burn is a deep one. A sufficiently accurate estimate of the area involved can be made by allowing 9 per cent for head and neck, 9 per cent for the upper limb, 18 per cent for the lower limb and 36 per cent for the trunk.

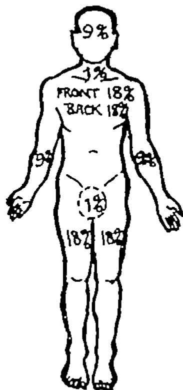


Fig. 123A. A chart of burn extent. (By courtesy of Mr A. B. Wallace and the Annals of the Royal College of Surgeons.)

Since this type of shock mainly depends on fluid loss

CHAPTER XVI

BURNS

"THE treatment of burns has lapsed into the realms of chaos," said Mitchiner, crystallising in this sentence the confused despair of everyone who has to deal with them Nevertheless, the essentials of management have remained the same from the era of carron oil to the era of penicillin They are —

(1) Treat the shock
(2) Clean the burn
(3) Prevent secondary infection and dressing trauma

It is over the best means of achieving (3) that there is so much disagreement

First Aid First-aid treatment is usually outside the surgeon's control, but if he has any say in the matter he should advise that the badly burnt patient be left alone and not subjected to the torture of removing garments from scorched flesh without analgesia, and that the less badly burnt should be protected from further contamination by a clean dressing

Morphine may be given freely to relieve pain and so ward off shock It should not, however, be allowed to take effect cumulatively, this may happen if repeated subcutaneous doses, given during a state of circulatory collapse, remain unabsorbed until the circulation recovers, when the body is suddenly flooded with the drug The intravenous route may be used to get round the difficulty, but has the drawback that, in the presence of peripheral and visceral vaso-constriction, the whole therapeutic effect may be diverted to the central nervous system

amount of urine secreted affords information which is almost as informative A catheter should be tied in and the bladder emptied hourly an output of 50 mls in an adult or 30 mls in a child is good evidence of a satisfactory circulation

Plasma should be dissolved in sterile pyrogen free distilled water If the solution fails to clear after filtering or shows any signs of precipitation moulds or other abnormalities it should not be used and whether satisfactory or not it should never be stored

When blood or any of its constituents is given to patients there is always a danger that it may contain a jaundice producing virus The jaundice does not develop until some months after the transfusion but the liver damage which accompanies it may be serious and may even lead to death The risk is much greater with serum or plasma than with blood because these are prepared from pooled stock This must be taken into account and weighed in the balance against their ready availability and universal compatibility In a case of burns the pros outweigh the cons In other cases the decision is a more difficult one But at all times the general principle can be laid down that transfusion of any kind is never a thing to be lightly undertaken

The Toilet of the Burn When shock is well under control (and this may not be for twenty four hours or longer in bad cases) the surgeon can turn his attention to the toilet of the burn This can usually be carried out under the narcosis produced by morphine But every now and again morphinisation fails to quieten the patient—perhaps a child—sufficiently and anæsthesia is required Even so it should not be pushed and the more toxic agents should be avoided

There is no excuse for skimping the full ritual of asepsis in a burn case Cap and mask gown and gloves are as

—from the burnt surface, into the neighbouring tissues, and into the tissues generally because of increased capillary permeability—prophylaxis and treatment largely take the form of replacing the fluid The simplest way of doing this is by giving the patient copious drinks of sweetened tea Unfortunately vomiting is common, and this method fails, especially in a bad case when the need is great The intravenous route must then supplement or replace it entirely

Formerly, on the principle of replacing like with like, these patients were given plasma only, blood being studiously avoided, because of the danger of increasing the hæmo-concentration already present It is now recognised that a deep or extensive burn, affecting 25 per cent or more of the body surface, causes wholesale destruction of red blood corpuscles in the capillary plexuses of the dermis, and that this loss contributes materially to the production of shock In such cases, therefore, whole blood may play a considerable part in the replacement therapy It should be given early, and constitute half the total quantity of intravenous fluid, plasma and saline alternately making up the other half

By allowing a litre to a litre and a half of fluid for each 10 per cent of burnt surface in an adult, and appropriately less in a child, it is possible to reckon roughly how much fluid will have to be given before the patient is out of danger On this figure depends the rate of administration, which will not be uniform, the need obviously being much greater at the start than later on when a balance has almost been restored The rule for large amounts is to give a third in the first eight hours, a third in the next sixteen hours, and a third in the last twenty-four

Definitive dosage is better controlled by watching progress and making repeated hæmoglobin and hæmocrit readings If laboratory facilities are not available the

a red hot iron usually destroys the whole thickness of the skin. The type of blistering is also helpful on occasion—the deeper the exudation the thicker will be the layer of epidermis raised over it *i e* the wall of the blister so the surgeon who finds himself snipping away thick walled blisters will suspect that he is dealing with a deep burn

Actually it is not until the blisters have been snipped away and the whole area cleaned that any reliable conclusions can be drawn As accurate an estimate as possible should be made because subsequent treatment depends on it

The appearances are as follows —

(1) Epidermis only destroyed	Red
(2) Part whole skin destroyed	Red and white
(3) Whole skin destroyed	White

The typical example of (2) is the burn in which the epidermis down to the papillary level has been destroyed and the dilated capillaries show as red pin points against a white background. Nerve endings as well as capillaries are exposed and the condition is extremely painful With whole skin destruction pain is often absent because the nerve endings no longer exist Here then is another aid to diagnosis—the patient with a painful burn can be put into category (2) if pain is not prominent he may belong to (1) or (3) Further evidence of a similar kind is to be had from the presence or absence of sensitivity to pin prick It should be remembered of course that a burn may vary from one area to another in depth of penetration Category (2) is often difficult to recognise and the surgeon must often be content to reserve his judgment perhaps for a fortnight or longer before he can be sure about it

In a first-degree burn (provided that infection does not turn it into a second or third) healing can be expected within seven to ten days In a second-degree it takes

necessary as when dealing with a wound or opening the abdomen Bacteriologists have shown that the burnt surface is commonly sterile at this stage To subject it to droplet or any other infection risk is therefore quite unwarrantable If the area to be dealt with is a wide one it should be tackled bit by bit, so that any particular part is exposed for the minimum of time In this way the danger of contamination is reduced and less heat is lost by convection

Gentleness is the prime consideration throughout the toilet Blisters are snipped away with a pair of scissors and a pledget of wool moistened in saline used to clean the burnt skin Spirit or ether are tissue irritants The urologist employs spirit to coagulate stray cancer cells This suggests very strongly that it can do no good to cells which have just experienced another form of trauma In the circumstances they are unlikely to tolerate anything but the gentlest and most considerate treatment that can be meted out to them

Epidermis, because of the exudation into it, separates very easily after a burn, and it is tempting to strip it far and wide Indeed, the nail brush has been called into service in the interests of thoroughness But stripping does far more harm than good The epithelial cells may be loosened by œdema, but they are still viable, and may live if given a chance Delicate swabbing is all that is needed to clear what superficial infection there may be It is true that the organism in the depths of the sweat and sebaceous glands will not be touched but no mechanical measures short of complete ablation can hope to reach them

The Depth of a Burn When a patient is first admitted to hospital it is never easy to be sure about the depth of a burn, although the history may give some indication—boiling water seldom does more than superficial damage,

The method puts a good deal of responsibility on the nursing staff and some ingenuity on their part is required in order to get good results The position to be adopted by the patient as he lies in bed depends on the site of the burn This must always be uppermost and must also be immobilised so that the newly formed coagulum does not crack A cradle or cradles covered by sterile towels with blankets on top are arranged as a protection against dust and to maintain the temperature Sometimes sus pension of a limb is advisable a sling from an intact wrist or ankle will probably suffice for this The gallows position may be useful in young children with scalds of the buttocks and is not resented by them although an adult would find it quite intolerable

Burns of the face one side of the trunk or perineum can all be dealt with satisfactorily in this way The neck and hands are more difficult to manage and when both sides of the trunk are involved the method is not appli cable because it is impossible to keep the under surface dry Burns encircling a limb are not suitable because contracture and constriction of the crusts might endanger the distal blood supply

Dressing trauma can be avoided or minimised in many other ways Coagulants for instance eliminate it com pletely together with all risk of introducing secondary infection But they are not applicable in third-degree burns because there is no epithelium left on the burnt surface to initiate healing under the tan There are other objections to their use which will be enumerated shortly

Historical. The bath treatment used in the early days of the war went a long way towards reducing dressing trauma The burnt part—or for that matter the whole body—was kept immersed in a saline bath for long stretches at a time In the intervals of immersion tulle gras dressings covered the affected areas and these

two to four weeks, depending on the extent and distribution of the epithelium that remains In other words, nature will do the job for herself in these cases if her efforts at repair are not hampered by careless dressing *Every separation of an adherent dressing injures delicate granulations and destroys regenerating epithelium* The patient's complaints and the bleeding from the raw surface are eloquent evidence to this, but they are often ignored

A third-degree burn will not heal until it is grafted

Doctors Differ The two essentials of treatment in first- and second-degree burns are —

(1) Prevention of secondary infection

(2) Avoidance of dressing trauma

How these are to be met constitutes a problem which has not yet been properly solved Some methods provide for one requirement, some for the other A few attempt to cater for both Be it noted that there is no difficulty about this so long as infection can be excluded and there is a sufficiency of surviving epithelium All that is needed to ensure success is a dressing fixed securely in place and left severely alone until healing is complete Unfortunately the necessary conditions are not always fulfilled, and compromise becomes inevitable

The Open Method The surest way of avoiding dressing trauma is not to use a dressing at all, and recent experience suggests that this may be the best solution of the problem in selected cases When a burnt part is exposed to the air the exudate dries and forms crusts within 48 hours, and these do not separate until healing has taken place underneath, which should be within three weeks—if it is going to take place at all In whole thickness burns the eschar is much tougher and does not come away within the time limit—evidence in itself that spontaneous healing is not to be expected

notable contributions to surgery He constructed a bag to take the place of the bath The Bunyan bag is made of oiled silk and fits the burnt part loosely but excludes air from it and is equipped with inlet and outlet tubes for irrigation by an antiseptic Oiled silk never becomes adherent to a raw surface even when the patient lies on it The antiseptic recommended by Bunyan was 1 per cent electrolytic sodium hypochlorite with 16 5 per cent sodium chloride added this to be diluted two to four times according to the depth of the burn and run through the bag for twenty minutes every four hours

Even an ordinary gauze dressing can be prevented from adhering to a burn if it is kept constantly moist This can be done by allowing saline to drip on to it from one or more bottles slung overhead or in a more simple fashion by dousing it from an undine every so often and discouraging evaporation in the intervals by swathing the part in mackintosh As has been suggested it is doubtful whether excessive moisture conduces to healing

The Closed Method Irrigation and baths abolish pain allow movement from the start and keep the part open to inspection throughout The chances of secondary infection are much less with the Bunyan bag than with an open bath with gauze soaks all depends on the pains taken in changing the dressings But this risk must always arise when a burnt surface is exposed in an ordinary ward before it has healed over The closed system provides the patient with the comfort and re assurance of a dressing and now holds pride of place in the treatment of burns The original objection to this system was that infection might flare up underneath the dressing and make considerable headway before suspicion was aroused temperature and pulse being the only guides to what was going on If this happened healing would not only come to a stand still but epithelium already present would probably be

remained in place until they were floated off in the next bath This technique was elaborated by the Air Force medical officers for some of the terrible cases with which they had to deal It throws a great strain on the nursing



FIG 130 A bad case of burns treated in an oiled silk envelope Mr Philip Cutner's patient

staff, opens the doors to secondary infection, and water logs the tissues if it is persisted in for very long

The idea was modified by Bunyan, a dentist in the Navy and by no means the first of his profession to make

dressing must not become an opportunity for fresh contamination The general ward is not a proper place for what is in fact a major procedure A draught free side room should be available full aseptic ritual practised and everyone concerned including the patient should be screened for throat or other infection that might be conveyed to the burnt area

The same tendency to exudation though less marked persists in a burn that fails to heal soggy granulations and surrounding œdema must be cleared away before epithelialisation can commence For these reasons pressure dressings are useful at all stages of treatment Elevation of the part is another very effective way of getting rid of surplus fluid and it should be arranged for whenever possible

Dressing inevitably immobilises to some extent but it is doubtful whether this does a great deal of harm if healing is rapid and it can be dispensed with at the end of ten days or so Nevertheless with a burnt hand it is wise to dress each finger separately and encourage movement from the start

Coagulants and Dyes The Chinese used tea as a lotion for treating burns 2 000 years ago no doubt because of the tannin contained in it The underlying idea survives in the open treatment and the principles are worth remembering

Certain claims are made for tanning –

(*a*) It checks fluid loss
(*b*) It checks protein loss
(*c*) It fixes toxins
(*d*) It eases pain
(*e*) It is a closed dressing

Healing under a tan mimics nature s healing under a scab but tanning has several drawbacks —

(*a*) A tan contracts and therefore healing under it may

dressing must not become an opportunity for fresh contamination The general ward is not a proper place for what is in fact a major procedure A draught free side room should be available full aseptic ritual practised and everyone concerned including the patient should be screened for throat or other infection that might be conveyed to the burnt area

The same tendency to exudation though less marked persists in a burn that fails to heal soggy granulations and surrounding œdema must be cleared away before epithelialisation can commence For these reasons pressure dressings are useful at all stages of treatment Elevation of the part is another very effective way of getting rid of surplus fluid and it should be arranged for whenever possible

Dressing inevitably immobilises to some extent but it is doubtful whether this does a great deal of harm if healing is rapid and it can be dispensed with at the end of ten days or so Nevertheless with a burnt hand it is wise to dress each finger separately and encourage movement from the start

Coagulants and Dyes The Chinese used tea as a lotion for treating burns 2 000 years ago no doubt because of the tannin contained in it The underlying idea survives in the open treatment and the principles are worth remembering

Certain claims are made for tanning —

(*a*) It checks fluid loss
(*b*) It checks protein loss
(*c*) It fixes toxins
(*d*) It eases pain
(*e*) It is a closed dressing

Healing under a tan mimics nature s healing under a scab but tanning has several drawbacks —

(*a*) A tan contracts and therefore healing under it may

lead to deformity—ectropion, a flexed elbow, or a claw hand

(*b*) If the tan encircles a part the consequences may be still more serious Contracture may cut off the blood supply to the extremity so that it becomes gangrenous, fingers and even limbs have been lost in this way

(*c*) A tan is slow to separate and may delay grafting This objection would scarcely arise if tanning was reserved, as it should be, for the case in which grafting is not necessary, *i e*, the first- or second-degree burn A much stronger objection to its use is that if sepsis develops underneath it the consequences may be unfortunate

(*d*) Tannic acid itself is not sterile To compensate for this it has been combined with various antiseptics

(*e*) There is more than a suspicion that excess of tannic acid may cause acute liver atrophy

For these reasons tannic acid itself has been given up Other agents give a more flexible tan, and still have their uses The dyes—gentian violet, brilliant green and acriflavine, alone or in combination, act as mild coagulants and may often be used with impunity on the face Their antiseptic properties argue strongly in their favour

Gentian violet, 1 per cent, is active against streptococcus, which appears in many burns at the end of twenty-four to forty-eight hours It can be sprayed on at intervals and the surface left exposed under a heat cradle For quick results silver nitrate may be used in combination

Brilliant green, 1 per cent, is inimical to gram-negative organisms Triple dye —

Gentian violet	1/400
Brilliant green	1/400
Flavine	1/1000

is active against both gram-positive and gram-negative organisms

All oil or grease must be cleaned away before the application and the usual thorough toilet carried out To neglect this or to employ tanning in a late infected case is on a par with closing an infected wound

Whole Skin Destruction Whole skin destruction whether immediate or arising as a result of sepsis in a burn of lesser degree presents a very different problem from that discussed above Here spontaneous healing is not to be expected Grafting is imperative and the sooner it is done the better In small deep burns especially those of the hands of the type caused by grasping an electric element or the splashing of molten metal it may be possible to excise and graft straightaway But in most cases the preliminary toilet must be followed by a period of systematic preparation before it is safe to apply the graft This may take anything between ten days to three weeks It should not be delayed longer The decision whether to use a flap or split skin will depend on the depth of destruction If tendon or bone is exposed then a flap is required Formerly these cases went through the long and dreary routine of daily dressings until the sloughs had separated and the granulations underneath had begun to take on a healthy appearance But there is no necessity for the sloughs to separate They can be cut away with a knife or diathermy and weeks or months saved thereby The procedure should not however become the occasion of further blood loss If for any reason surgery is undesirable dressing with 5 per cent sodium hypochlorite solution a forty-eight hour application of a starchy solution of pyruvic acid 7 mls to the litre or daily immersion in a bath for twenty or thirty minutes will produce a similar effect though not so rapidly

Even when the sloughs have gone the underlying granulations will still be pale and unhealthy with a tendency to suppurate Local applications and *pressure*

must be continued until they present a smooth, compact appearance with a uniformly pink colour Anti-biotics are seldom of much service at this stage, but if culture shows that the organisms are still sensitive they may be used on the dressing for the last forty-eight hours before grafting

The Chronic Case The patient with unhealed burns is almost always anæmic, and it is an essential part of the treatment to correct this Hæmoglobin should be kept at 80, by transfusion if necessary It is useful to remember that a pint of blood cannot be counted on to raise the hæmoglobin more than 7 per cent in an adult, so the allowance may need to be generous In addition to the anæmia there is a notable hypoproteinæmia to be reckoned with, but this can usually be countered by dietary measures Until these deficiencies are remedied progress is likely to be delayed

So long as healing is incomplete there is a danger of contracture, and it is only by exercises started early, and attention to the position of the part maintained throughout the treatment, that it can be prevented from marring the end result

CHAPTER XVII

PLASTIC SURGERY

Whole thickness and Part thickness Skin Grafts Broadly speaking skin grafts can be divided into epidermal or part thickness and dermal or whole thickness There is a sharp distinction between the two depending on the different way in which they are nourished The epidermis is avascular and nourished by lymph the dermis has a *blood supply of its own with a capillary network projecting* into its papillæ (from which comes the lymph for the epidermis) This being so it is easy to understand why an epidermal graft takes so much more easily than a dermal. It has no need to become vascularised but can satisfy its requirements in the exudation from any raw surface in contrast to the dermal graft which must pick up a completely new blood supply before it establishes its right to survival It is because of this important difference that while epidermal grafting comes within the province of the general surgeon dermal grafting must nearly always remain a preserve for the specialist. This would not matter so much if there were little to choose between them but unfortunately this is not so An epidermal graft must always take second place to a dermal whether from point of view of appearance or function no true foundation ever develops underneath it to give it suppleness and resilience and it can never stand up to the same wear and tear as whole-thickness skin

The Donor Area The donor area for a graft should

(1) Be in a concealed part of the body
(2) Provide a suitable type of skin
(3) *Be quite free from infection*

Thiersch and half-thickness grafts are taken most easily from the inner or outer side of the thigh and the front of the arm (this is freest from hair) where the skin can be stretched over a firm background of bone A Wolfe's graft, being cut in an entirely different way, may be taken from the abdominal wall or any other yielding part of the body

Shaving followed by washing with ether soap is sufficient preparation for the selected site—antiseptics are better omitted



FIG 131 Ugly scar left after taking a Reverdin graft

After removal of an epidermal graft the area will epithelialise like a superficial burn if left to its own devices It should be covered by tulle gras and gauze soaked in flavine emulsion, the dressing not being disturbed for seven or eight days, by which time healing ought to be complete The gap created by excision of a Wolfe's graft can sometimes be closed by undercutting the edges and stitching them together, but Thiersch grafting may be required to cover it in some cases

Whenever possible it is better to have done with the donor area before tackling the receptor Otherwise there is a risk of transferring infection from the one to the other In Reverdin grafting the accident is not uncommon

Reverdin Grafts Reverdin grafts are small circular islets thicker in the centre than at the periphery obtained by picking up cones of skin on the point of a needle and cutting across their base with a sharp scalpel These islets are planted in rows over the receptor area The result as might be expected is not cosmetically good and healing at the site from which the grafts are taken leaves



FIG 132 A Humby's knife at the end of the cut depth is regulated by adjustable screws at either end of the blade which the surgeon should set himself.

an ugly scarring This method once popular because it can be used in cases not yet free from infection has been given up in favour of patch grafting which gets round the all-or none difficulty in take equally well

Epidermal Grafts There are two types of epidermal graft—the tissue paper Thiersch and the half thickness With the lapse of time both tend to change colour becoming either paler or darker than the surrounding skin the Thiersch being the worse offender of the two They are

not suitable, therefore, when appearance is a prime consideration Also they do not stand up well to rough usage, so they cannot be used in areas exposed to pressure or friction And they should never be employed as permanent covering for moving parts, such as tendon or muscle, because they inevitably become closely adherent to whatever lies underneath They will not survive on cortical bone, but do on medullary, *e g*, the end of an amputated phalanx



FIG 133 A "patch" graft can be cut with a Bard Parker blade

Cutting of these grafts is an art that can only be learned by experience, although the Humby knife goes a long way towards eliminating the individual factor Some of the essentials to success are —

(1) Lubrication of blade and skin with glycerine

(2) Proper tension on the skin This is maintained by two slats of wood, one held by the surgeon, the other by his assistant

(3) Never moving the slats while the knife is cutting

(4) A sawing movement of the blade without pushing

(5) Attention to the colour of the graft as it separates

A Thiersch is a transparent blue A half thickness is



FIG. 134 (a)

off white A dead white colour or the appearance of subcutaneous fat behind the blade means that the cut has gone too deep when this happens there is no alternative but to make a fresh start elsewhere it is waste of time to try to diminish the depth of the cut

Handling of the graft is better avoided altogether and

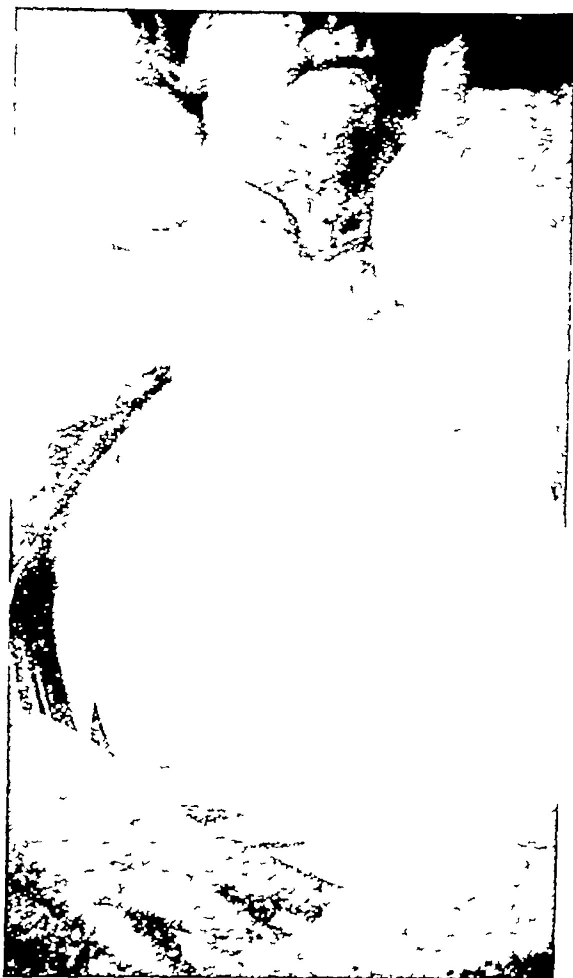


FIG 134 (*b*) Immediate grafting after a breast operation with the end result

only the finest of instruments should be allowed to come into contact with it, delicate skin hooks replace dissecting forceps and even these must be used with circumspection

A graft should not be allowed to dry,[1] and if there is

[1] Grafts can be stored in a refrigerator in sealed bottles but these cannot be used for another patient homo grafting nearly always fails, even when bloods match skins do not

any delay during the operation it should be wrapped in gauze soaked in saline

Receptor Area A receptor area should be healthy How healthy is something of a problem The tendency nowadays is to be less insistent than formerly on optimal conditions for an epidermal graft but there is no relaxation where a full thickness graft is concerned On granulations or fibrous tissue this is *certain to necrose it will not* survive on anything but a clean excised wound and



Fig 135 Fibrosis progressing steadily under granulation tissue, first second, and third weeks.

there can be no doubt that any other type of graft does better on such a surface It follows from this that the best time for grafting of whatever kind is the time at which the skin is lost before infection has set in and not weeks later when the wound is covered with granulations and its blood supply is reduced by underlying fibrosis Unfortunately there are often contra indications to immediate replacement After an injury infection may be already established With a burn of any extent delay is unavoidable At the end of a long operation the patient s general condition may not permit any further interference

Cases of this type go through a reactionary stage of more or less severity and it is only when this has subsided

that a graft is likely to "take" The greater the delay the more will be the underlying fibrosis Three weeks should be sufficient to give a surface on which —

(*a*) Granulations form a smooth red carpet

(*b*) Discharge is scanty, colourless and free from hæmolytic streptococci

(*c*) *Epithelium is beginning to creep in all round the edges* This is a sign that Nature herself is satisfied with the situation

Failing those conditions the graft may not be a complete success, though the operation may still be justified

Even when every requirement is fulfilled the granulations are better removed They can be raised in one compact layer with the felt of fibrous tissue on which they rest by scalpel dissection In the more chronic cases it is important to get rid of every particle of scar tissue, and to restore the *status quo* as far as possible At the same time the margins of the area should be undercut a little to release them This permits a slight overlap and allows for contracture in the graft during healing

Hæmostasis is the next problem But if the dissection has been carried through at the right depth there should only be slight bleeding, most of which will stop with the pressure of a hot pack (Swabbing aggravates it) Any points that still ooze can be touched with a pledget of wool soaked in adrenalin, or they may be dealt with by crushing If this does not succeed they may be tied off with the very finest of material, using only a single hitch on the knot Diathermy is not permissible because of the necrosis it causes, and even the tiny ligature is apt to give trouble , for this reason some surgeons make a point of nicking the graft exactly over it so that any irritation it may set up will be localised

The area, being now clean and dry, is covered *com-*

pletely with the graft [1] If in spite of all precautions there is still a chance that hæmorrhage or exudation may lift it from its bed provision must be made for drainage This can be done by making nicks all over it with the points of a pair of scissors or better still when the danger is great by cutting it up into postage size patches and applying them separately a patch will sometimes take next to a slough

Maintaining Close Apposition Next comes the question of how to maintain the close apposition between graft and bed during the ensuing week If the surface is a resistant one *e g* forehead or shin the graft can be placed raw side out on a square of tulle grass which is laid on the bed and anchored to the adjacent skin by fine horsehair stitches the ends being left long This is covered with wool pledgets wrung out of an emulsion of flavine and paraffin and held in place by tying the ends of the stitches together on top of them The surrounding skin is then painted with mastisol so that the first turn of bandage sticks to it and further immobilises the dressing

If on the other hand the surface being dealt with is a yielding one a stent mould must be used to get the necessary pressure The mould softened by immersion in hot water is first pressed firmly into the prepared bed until it sets It is then removed and the graft spread over its convexity It is now replaced in the bed and held in place by stout mattress sutures taking deep bites of the skin on either side If the part is movable some form of splinting may be desirable and there is nothing more satisfactory for this purpose than plaster of Paris

In a clean case the dressing should not be disturbed for a week Where there is a likelihood of infection or if discharge shows on the surface it may be advisable to

[1] Granulations sprout vigorously beside and between grafts delay healing, and may develop into keloid

remove at least the outer layers earlier than this, but every care should be taken not to disturb any part of the graft that may have adhered

A Graft as a Physiological Dressing If for one reason or another a reconstructive operation has to be delayed for a considerable time it is often possible to cover the area with a Thiersch graft quite early on This may have to be replaced later by full-thickness skin, but meanwhile further infection is completely excluded, and resolution progresses more rapidly than under any other form of dressing A Thiersch is, in fact, the ideal form of occlusive dressing

Wolfe's Grafts A Wolfe's graft is full-thickness skin but no more, not a particle of subcutaneous fat is included It is cut with absolutely vertical edges to fit the defect accurately This can be done by preparing a templet of tin foil to the required shape and size, laying it on the donor area, outlining it in Bonney's blue, and cutting along this line with a sharp scalpel The excised graft is then denuded of any remaining fat by means of a small pair of scissors curved on the flat In spite of the likelihood of shrinking it should be slightly on the stretch when it is stitched in position and, as with other types of graft, it is wise to nick it here and there for drainage A firm dressing is required, but excessive pressure should be avoided, this dressing is left untouched for a fortnight This type of graft always desquamates and often becomes discoloured, but nevertheless survives It is, however, peculiarly liable to a spreading necrosis if fluid is allowed to accumulate underneath it Any area of softening should therefore be incised without delay

Flaps A flap is, of course, the most satisfactory of all replacements Not only is whole skin used, but subcutaneous fat as well, and blood supply is retained, so that the end result is as near an approach to normal as

possible This is the type of replacement that is most suitable for covering parts subjected to any strain whether from within by the drag of tendon or muscle or without

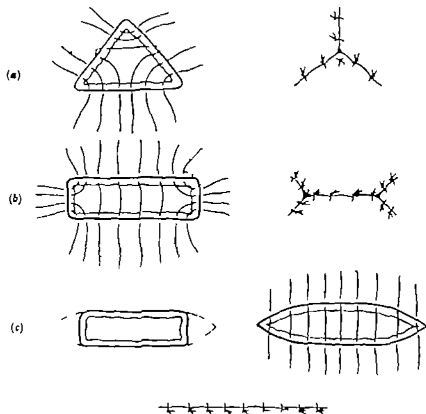


Fig 135A Advancement flaps. The dots indicated the extent of under cutting required After a drawing by Mr F T Moore in the *Post Graduate Medical Journal*

by weight bearing and it is the only type which survives on an avascular bed—a free graft of any thickness will not take on bone or muscle because it cannot acquire a blood supply

But the business of fashioning flaps and preparing

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with scarring running across a flexure If such a scar is merely excised the second scar is just as likely to contract as the first By cutting flaps and transposing them the

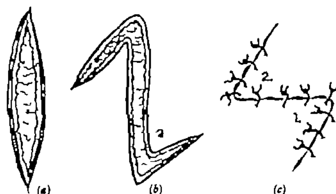


FIG 137 A hypertrophied scar crossing a flexure can be excised (a) but if it is stitched up again as it lies, fibrosis will recur By adding oblique incisions at either end (b) undercutting them, and reversing the flaps so formed (c) the scar can be made to lie along the flexure instead of across it

new scar can be made to run at right angles to the original (Fig 137) The method is applicable in the neck axilla antecubital fossa etc.



FIG 138 A small triangular wound can be brought together by undercutting and using a st t h of this type

(3) *Local Flaps and Approximation Flaps* A flap of skin is left attached at one end while the other is applied to the receptor area The operation is completed in three or four weeks time when a new blood supply

pedicles is a complicated one, and should be left almost entirely in the hands of the plastic surgeon

There are various procedures —

(1) *Advancement Flaps* A simple undercutting of wound edges is an example of this The extent of undercutting required varies from five to ten times the size of the gap to be closed, depending on the elasticity of the skin in the part The scalp is quite inelastic, and even

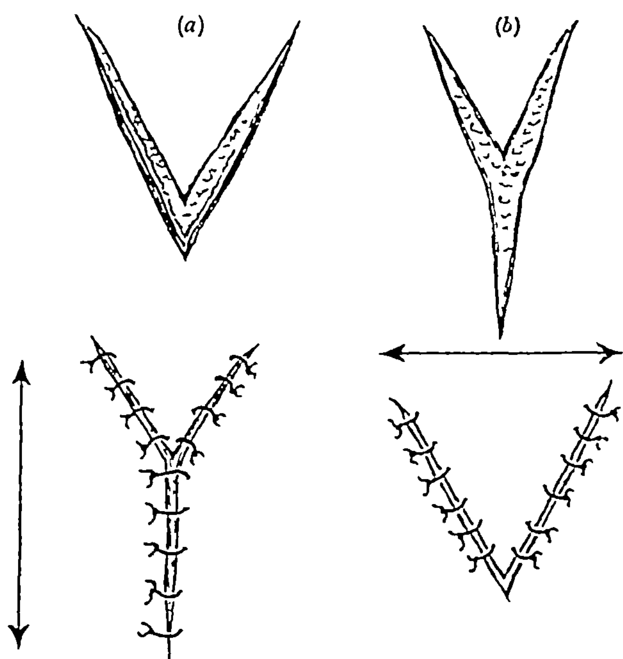


FIG 136 (a) A V incision stitched as a Y gives added strength (b) A Y incision stitched as a V gives added breadth

small defects in it may be difficult to repair in this way Diagrams show examples of rather more complicated flaps The V incision stitched in Y, which gives additional length, and the Y incision stitched in V which gives additional breadth are others

(2) *Transposition Flaps* These can be used to deal

burns than in wounds although incisions which cross the lines of flexure are almost certain to produce it The chest is the commonest site where it often follows injudicious interference with moles or warts in young girls these are usually much better left alone

The first rule of treatment is that interference should not be precipitate especially on the chest where recurrence is common

Case Note A little girl was seen with a mass of keloid on her back following a burn. Various means of getting rid of it were discussed but it was decided to do nothing until the summer holidays By then it had entirely disappeared

When action must be taken either for cosmetic reasons or to put an end to itching and irritation it is probable that surgical excision with the strictest attention to aseptic technique followed by the application of radium to the healed incision or edges of the graft (if grafting has been necessary) is the best form of treatment Radium by itself destroys keloid but its action is slow

has been acquired by dividing the flap, leaving its extremity to make up the defect, and restoring its pedicle to where it came from Examples are the forehead flap to the tip of the nose and the flap raised from the abdominal wall to cover a denuded hand

(4) *Pedicle Grafts* These are grafts prepared in the form of a tube which remains attached at both ends until its blood supply has acquired a linear distribution One

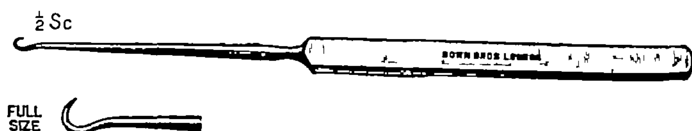


FIG 139 A toothed dissecting forceps traumatised the skin a non toothed forceps does not grip it A hook retractor of the Gillies type can be used as a substitute (*By courtesy of Messrs Down Bros*)

end is then detached and swung to a new site nearer the receptor area Here it is left for a further period before the next swing And so on until it has reached its objective

Storing of Grafts A graft can be stored for as long as a month by spreading it on a piece of tulle gras and wrapping this up in a saline swab, which is placed in a sealed receptacle in the refrigerator It may be convenient to preserve homografts in this way These grafts, taken from another individual, only survive for a matter of weeks on the recipient, but they sometimes provide very useful temporary cover when there is no other donor area available

Keloid Keloid, an excess of fibrous tissue in a scar, at first vascularised but later becoming ischæmic, is more often seen around the neck and in front of the sternum than in other parts of the body Some people are more prone to produce it than others, notably the red headed and dark skinned, and more particularly between the ages of three and seventeen It is more likely to appear in

may be discovered between a growth and an important artery or a duct or a bone Bone though very subject to metastasis is not readily breached from without unless it becomes secondarily infected

To talk of a tumour and its capsule or of enucleating a tumour with its capsule is a mistake the capsule belongs to the surrounding tissues and is only attached to the tumour over a small area A tumour can be *excised* with its capsule intact but when it is enucleated the capsule remains behind so it is fortunate that only innocent tumours possess well defined capsules it is true that some connective tissue tumours may have a fibrous investment but this presents no plane of cleavage on either of its surfaces

Nature s Channels Unfortunately there is a reverse side to this picture The lines of lesser as well as the lines of greater resistance must be taken into account Cancer spreads quickly along tissue interspaces and the natural channels formed by lymphatics and veins

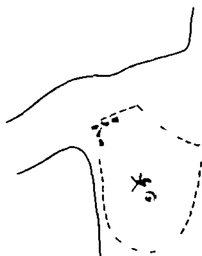


Fig 140 A block dissection for carcinoma of the breast



Fig 141 A block dissection for carcinoma of the colon

CHAPTER XVIII

SURGERY OF MALIGNANCY

It is a sad business for the surgeon who sets out to rid a patient of a malignant growth only to find after the lapse of a few months that he has been responsible for disseminating it Of course this is more likely to happen in an advanced case than an early one, but every now and again it occurs when prospects of cure seem brightest An example of such a catastrophe is given later in the chapter There may be an error of technique in these cases, but the trouble can often be traced to an ignorance of pathology

Nature's Barriers The local extension of a growth is not necessarily equal in all directions Some structures are resistant to its spread, others yielding The capsule of an organ will contain it for months or even years We have all seen the liver with a capsule which is quite intact although enormously distended by secondaries So also in the other solid viscera, and in the lymphatic glands, a gland may be crammed with cancer cells and still perfectly discrete and unattached

These barriers must not be broken down by surgery A malignant growth should not be cut out of an organ when the whole organ can be removed without detriment to the patient Biopsy by excising a fragment of a primary growth is inadmissible when there is an involved lymphatic gland nearby which can be enucleated entire And rupture of such a gland during the procedure must be avoided at all costs

Per contra, it may be well worth while dissecting a closely adherent mass away from a structure which is resistant to its spread For example, a line of cleavage

may be discovered between a growth and an important artery or a duct or a bone Bone though very subject to metastasis is not readily breached from without unless it becomes secondarily infected

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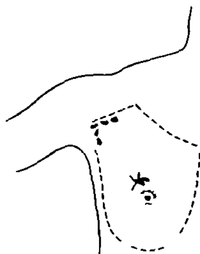


FIG [illegible]4 A block dissection for carcinoma of the breast.



FIG 141 A block dissection for carcinoma of the colon.

Moreover, its microscopic edge is always well in advance of its macroscopic

Sampson Handley's theory of lymphatic permeation has now been largely given up Most surgeons believe that the lymphatic metastases like the venous are embolic, at least in the earlier stages of the disease Nevertheless a *block dissection of growth and glands in one piece* is still the ideal to aim at Where it cannot be achieved, as with growths of the mouth, as wide a clearance as possible of the growth itself should be carried out to allow for microscopic extensions of the growing edge

The Part Played by Infection Neoplasia is often accompanied by infection, even in the pre-ulcerative stages Dense adhesions round a growth may be simple in nature, glandular enlargement may be inflammatory and not metastatic in origin

Mistakes arising from this are particularly common with pelvic cancer, though they may occur with any intestinal growth

Case Note At laparotomy a recto-sigmoid growth appeared inoperable, the pelvis being occupied by an adherent mass glued to the back of the bladder However, an abdomino-perineal resection was eventually completed The growth proved to be a ring scirrhus without extensions All the induration and adhesions were inflammatory

Case Note A right hemi-colectomy was performed for removal of a mass in the ascending colon as big as a coconut The specimen showed a malignant ulcer the size of a five shilling piece based on a para-colic abscess which was encased in dense fibrous tissue

Is Cure Possible ? A growth may be labelled incurable because of its size or fixity, or because it has given rise to remote metastases The two kinds of incurability are different The first might be termed relative being influenced by extrinsic factors, such as the presence or absence of inflammation, the caution or daring of the

surgeon etc The second used to be considered absolute but in recent years solitary metastases in liver and lung have been removed with a measure of success and amputations have been performed to get rid of bony secondaries

In recent years the tendency is to make less and less of technical difficulties Growths which would have been considered quite hopeless a decade ago are now tackled as a routine and often with surprisingly good results The size of a tumour often bears little relation to its operability An investigation at St Mark s Hospital has shown that in a series of rectal carcinomata the group which proved on laparotomy to be bulkier than the average—say as big as a coconut—gave better results than the group which proved to be smaller—say as big as an orange. This observation merely underlines a fact that was already well known infiltrating growths are more malignant than proliferating

It is no uncommon thing nowadays to see more than one organ removed in order to get clear of all extensions the spleen is taken with the stomach and perhaps part of the pancreas as well the uterus is taken with the rectum when both are involved Moreover where formerly some form of short circuit was considered all that was necessary as a palliative nowadays a resection is frequently carried out although distant metastasis has already commenced So a partial gastrectomy may replace a gastro-enterostomy for a carcinoma of stomach with small secondaries in the liver and an abdomino-perineal may be performed under like conditions

Where cure is possible there is only one safe principle to work on—that if a single gland containing a secondary deposit is left behind the disease will recur This is a sanction that can never be ignored no matter what the circumstances

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Is Cure Possible ? A growth may be labelled incurable because of its size or fixity, or because it has given rise to remote metastases The two kinds of incurability are different The first might be termed relative being influenced by extrinsic factors, such as the presence or absence of inflammation, the caution or daring of the

towels should be clipped to the edges of the incision in the bladder so as to exclude the wound completely from the field of operation the growth should be cauterised at once with a swab soaked in 10 per cent silver nitrate the greatest care should be taken to prevent contact between it and the mucous membrane during removal and the bladder should be thoroughly washed out with 1/1000 silver nitrate solution at the finish Papillomata of the renal pelvis are equally treacherous Treatment is by nephro-ureterectomy without opening the pelvis

More solid growths whether in the urinary tract or elsewhere are less likely to scatter seedlings while being removed but this does not mean that it is safe to take any risks with them The gynæcologist is at great pains to keep a carcinoma of cervix confined within the vagina during a Wertheim s hysterectomy for fear of spilling cells into the pelvic cellular planes The mixed salivary tumour recurs with monotonous regularity after removal no matter what precautions are taken and the recurrence is often malignant no matter what the nature of the original A surgeon therefore when operating on a potentially malignant tumour can never be too careful to keep well clear of it

When biopsy is essential for diagnosis as it often is in the breast it is safer to cut the whole mass out before cutting into it If operation follows at once the surgeon should put on fresh gloves and change all his instruments Preliminary biopsy of superficial or ulcerated growth carries no dangers

Risks of Releasing Emboli With certain cellular highly malignant growths such as sarcomata teratomata chorion epitheliomata hypernephromata a still graver menace than transplantation of cells threatens the patient These tumours are very vascular and manipulation (pre operative as well as operative) may release emboli into

Towards the end of a long operation the temptation to get finished and done with may be very great indeed The patient is probably beginning to show signs of shock, the anæsthetist is getting fidgety, and the surgeon is tired But an extra five minutes on the table may make all the difference between success and failure Whatever the result, a year or two goes by before it becomes known, and by then no one remembers the operative details, the notes only record what was done, and make no mention of what was omitted Nevertheless cause and effect bear their usual relationship, and the surgeon who is honest with himself accepts his responsibility

Risks of Transplantation Under certain conditions it is the easiest thing in the world to transplant malignant cells

Case Note A partial gastrectomy was carried out, although the growth had reached the peritoneal surface of the stomach Two months later the patient returned with his abdominal wound heavily infiltrated by growth A similar thing happened to another patient after a laparotomy for what proved to be a carcinomatous ascites

In these cases the seed was plentiful and the soil was suitable A fatal outcome must have been inevitable whatever happened But with certain papillomatous growths of the urinary tract the prognosis may be entirely altered by operation

Case Note At operation for enlarged prostate a small papilloma was found in the bladder close to the orifice of a diverticulum It was destroyed by diathermy at once without even taking a snip for section, and the diverticulum was left untouched Three months later the patient returned with widespread carcinomatous invasion of his bladder base and supra-pubic scar

Every effort should be made to treat vesical papillomata by trans-urethral diathermy If operation is necessary

may develop and carry the patient off more quickly than a miliary tuberculosis

Grading a Growth. There are two methods of grading a growth—by the character of its cells or by the stage to which it has progressed at the time of operation For

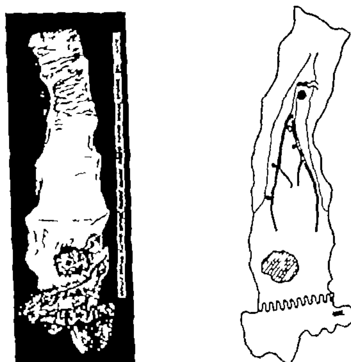


FIG 141A. A method of recording the spread of a growth, from *The Principles and Practice of Rectal Surgery* by Gabriel (H K Lewis & Co Ltd)

obvious reasons the two will often correspond fairly closely but this is not always so

Staging will vary from organ to organ In the breast for instance Stage I is a tumour confined to the gland Stage II shows mobile glands in the axilla Stage III is advanced with local or remote metastases In the bladder Stage I is a growth confined to the bladder wall Stage II shows involvement of the peri vesical tissues Stage III

the circulation to be carried to the lungs and perhaps from there all over the body   Incision before excision is therefore completely inadmissible, and an attempt should be made to cut off the blood supply before the tumour is even touched—with the testis, for instance, this can be done quite easily by clamping the cord high up

Anomalies   So far as the surgeon is concerned, the lymphatic spread of cancer is all that matters   He cannot hope to overtake blood-borne metastases   But even in dealing with lymphatic spread there are many factors outside his control

The microscopic character of the disease is a handicap from the very start   Cancerous emboli probably consist of aggregations of cells   Nevertheless on first lodgment their size must be minute   So a gland which is hardly large enough to call attention to its own existence may already conceal a metastasis   That is why it is important to clear out *all* the fat and cellular tissue in a danger area

The uncertain distribution of the lymphatics and the sluggishness of the lymph stream are bound to produce other anomalies   When a gland becomes blocked by inflammation or choked with metastases its tributaries open into collaterals and discharge their contents elsewhere—a cancer on one side of the tongue may involve the opposite side of the neck, a cancer in one breast may even involve the opposite axilla   A complete reversal of the lymph flow is not uncommon, and this explains how a cancer of the stomach may give rise to deposits in the lumbar glands   And there is always a danger that lymphatic spread will undergo a sudden transformation into something much more rapid   A major vein may be invaded, either directly or through the thoracic duct   An overcharged lymphatic may rupture into the peritoneal cavity and sow it with malignancy   A miliary carcinosis

high frequency current which enters the body through a large electrode and leaves through a small one generating increasing heat along its path until tissue is destroyed at the point of exit

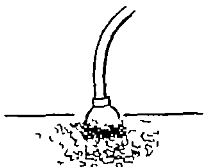


Fig. 143. Cauterisation with a ball electrode sets up a barrier of dead tissue which checks further penetration.

The large electrode consists of a flat metal plate completely enclosed together with its screw terminal in a calico bag which is soaked in strong saline before use (10 per cent or a handful of salt to the pint) This is placed under the buttock so that it makes firm and even contact over its entire surface any neglect here may cause a burn The small electrode is mounted on an insulating handle and may be a needle or a button according to whether cutting or coagulation is required (for each of which a separate circuit is provided

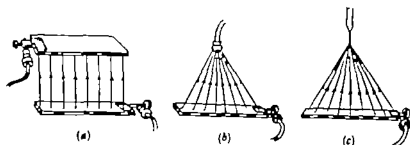


Fig 144 (a) Medical diathermy "heats the tissues (b) Diathermy with a ball electrode coagulates. (c) Diathermy with a needle cuts.

inside the machine) The strength of current needed should be determined beforehand and not at the time of operation allowance being made for the fact that fat is a poor conductor and that denser structures resist dissolution The rate of oscillation of these currents is too rapid to stimulate muscle or nerve but unfortunately undertones

affects the local glands, and Stage IV has remote metastases

Although these classifications may be quite misleading, they are very often useful both in prognosis and for statistical purposes For ease of reference it may be convenient to record them in pictorial or diagrammatic form (Fig 141A)

It is perhaps worth mentioning that the pathologist's report on a specimen may be considerably influenced by the information he gets with it Specimens should therefore be carefully and completely labelled, and when necessary discussed with the pathologist, who may sometimes revise his opinion when he knows the full facts of the case Certainly he should never be asked to carry out his task with no more help than is supplied by the identification tags fixed to the bottles by the nursing staff Even these are not noted for their immunity from error

Surgical Diathermy The surgeon in the ancient world was enjoined to " burn a tumour out with fire so that it may not bleed freely " His successor uses the diathermy for the same purpose It depends for its effect on a



FIG 142 A patient in the lithotomy position If diathermy is to be used the right thigh should be insulated from the pole Otherwise a burn may result

Occasionally an innocent skin tumour—a small angioma for instance—can be destroyed by multiple punctures with a coagulating needle but there is a danger of sloughing and even secondary hæmorrhage if too much is attempted at one sitting These complications are luckily uncommon because charred tissue loses its conductivity and so sets up a barrier against spreading destruction

Diathermy can also be employed for malignant skin tumours which have broken down and become infected With some of these a total excision by the cutting current leaving a clean granulating surface is possible

Surgery and Irradiation Irradiation affects malignant cells in two ways—directly and indirectly It has a direct destructive action on the cells themselves the products of this destruction then lead to a hyperæmia and diapedesis followed by a connective tissue reaction which further indirectly damages the cells

Unfortunately the healthy surrounding tissues suffer also though not to the same extent Of these from the surgeon s point of view the most important is the skin Erythema is invariable and may take a week or more to subside sometimes desquamation follows especially if the part is not kept absolutely dry Because of the skin reaction post-operative irradiation cannot be started until healing of the wound is complete This detracts from the prophylactic value of the irradiation

The difficulty is encountered most often in breast surgery and when it seems likely either from the size of the tumour or its situation in the breast or the type of breast being dealt with that grafting will be necessary at the close of the operation some surgeons prefer to irradiate pre instead of post-operatively This reversal of procedure has the added advantage that it sometimes brings a seemingly inoperable tumour within range of the knife Against it is the fact that hæmorrhage may be

capable of doing this can never be completely eliminated, and twitchings caused by them are unavoidable

Diathermy should never be used on skin recently painted with spirit, nor in the presence of an inflammable anæsthetic As a substitute for the knife it has the advantage that it seals small vessels and lymphatics as it cuts, and kills any stray malignant cells in its track though " the more the cutting the less the coagulation "

But experience is needed in the handling of the needle A little extra pressure or a momentary hesitation in the cut may do harm This is not an instrument to choose when accurate dissection is required In the axilla, for instance, it has no place, and even in the removal of a breast it must be kept under careful control

Case Note A post-mortem is on record of a woman who died following a breast amputation by diathermy She had a pyo-pneumothorax caused by sloughing of an intercostal space

Healing is slower after diathermy (though less painful, because the nerve ends are fixed), and there is a tendency for serum to collect in the wound Most surgeons have

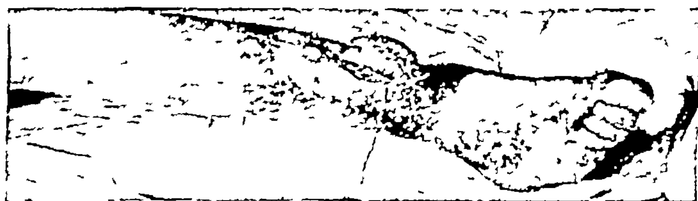


FIG 145 This granuloma was excised by diathermy and the area successfully grafted (Mr Desmond Cooper's case)

abandoned the method in breast surgery, but it is still used for malignant disease in the mouth When this is advanced and the jaws are involved there is considerable danger of necrosis following the treatment, bone being peculiarly vulnerable to heat

CHAPTER XIX

SURGERY OF CHILDREN

By C F CRITCHLEY MS FRCS

UNDER favourable conditions infants and children make surprisingly good patients but they react badly to exposure rough handling or shock a bungled attempt to start a transfusion has tipped the scale against recovery more than once in a young child. It follows that heroic surgery plays no part in pædiatrics but conservative surgery may be undertaken with every confidence if pre and post-operative treatment is properly carried out

The Age for Operation Infants a few hours old are operated on for such things as exomphalos congenital atresia of the gut meconium ileus imperforate anus and retention of urine These being emergencies any delay would be fatal But in the ordinary run of cases the generally accepted principle is to postpone interference until the parts are reasonably developed and the bodily resistance increased always provided that the delay does not aggravate the lesion or diminish the chances of cure Julius Woolf enunciated the law that —

Structure is adapted to function

and very often the decision when to operate is governed by the application of this law to the case under consideration A cleft palate for instance should be closed before the child develops bad habits of speech and before the dentition and contour of the face are adversely affected This means operation at or about the age of two Similarly talipes should be corrected before walking commences and the deformity becomes fixed On the

slightly more troublesome than usual, and tissue planes not quite so easy to define After heavy or prolonged irradiation there may even be pronounced fibrosis But these are obstacles that can be overcome

A more serious consideration is that the treatment may cause a grave deterioration in general health A woman suffering from irradiation sickness is scarcely a fit subject for general surgery, and it may be several weeks before her condition improves sufficiently to undergo it Meanwhile she is never free from the danger of metastasis

posteriorly thus opening the larynx to foreign bodies For this reason operations on the head and neck are best done with the head fully extended unless the pharynx is packed

The liver is relatively larger than in the adult its edge being one or two fingers below the costal margin In operating for congenital pyloric stenosis advantage is taken of this fact by making the incision high up so that the liver presents immediately the peritoneum is opened prevents eventration during the operation and enables the abdomen to be closed easily and quickly at the end

The intestine is only half the adult length one reason why resection in a child carries such a high mortality Sacculations do not appear in the caecum until the third year and this may cause confusion in the right iliac fossa The omentum being short and undeveloped puts up little defence against the spread of infection In consequence appendicitis very easily leads to peritonitis The danger of delay in operation is correspondingly increased and conservative methods of treatment are inadmissible before the age of twelve

Infant bones are soft and malleable because of the higher proportion of fibrous tissue and spongy bone This is especially noticeable in the chest where any obstruction to respiration is soon followed by deformity Even inadvertent pressure during the course of an operation is enough to mould rickety bones

The periosteum is thick and strips readily This accounts for the number of green stick fractures seen in children as also for the ease with which they are reduced. In operating for osteomyelitis the tendency of the periosteum to strip far and wide may result in a large area of bone being deprived of its blood supply

To the elbow they go from the knee they flee is an old mnemonic which helps the student to remember

other hand, it is better to delay operation on umbilical and inguinal herniæ. In the former, strapping skilfully applied will probably make surgery unnecessary. In the latter the gossamer texture of the sac and the delicacy of the structures encountered makes operation in the very young an exasperating and unsatisfactory business. Sometimes, however, a big hernia causes so much trouble that the parents refuse to be put off any longer, and the surgeon is forced to go ahead with it; in a case of this kind he will usually be relieved to find that " function " has thickened the sac so much that it can be dissected out without any great difficulty. Operations for ectopic or imperfectly descended testis need not be undertaken until the age when the normal testis begins to develop—that is to say at eight or nine years—but they should be completed before puberty. Certain operations, notably those on the nasopharynx, should be temporarily postponed if respiratory infection is prevalent or poliomyelitis reported in the neighbourhood.

Anatomy. The anatomy of the young child differs in many ways from that of the adult, and the differences have an important bearing on surgical technique.

A child's head is relatively large with prominent scalp veins which may be used for infusion and transfusion by the surgeon who is expert with a needle. The anterior fontanelle remains open up to two years, but few people nowadays have the temerity to take advantage of the easy access it affords to the sagittal sinus.

Teeth are not normally present in the newborn, and this together with the under development of the lower jaw makes it difficult to gag open the mouth.

An infant's neck is short, and in the early days its movements are restricted. This must be remembered when arranging the position on the table.

The edges of the epiglottis in childhood are folded

The average blood volume in the adult ranges from about 3 300 ml to 7 000 ml varying with weight sex etc In the newborn infant the average is about 300 ml rising to 600 ml at one year It is obvious then that while a certain amount of hæmorrhage in an adult during the course of an operation may be of small moment in an infant it is often a serious matter It would appear moreover that the bleeding time in infancy is prolonged particularly during the neo-natal period Hæmostasis therefore must be meticulous in the young

Infusion and Transfusion Dehydration is an important factor in the production of shock It is precipitated by pyrexia vomiting or diarrhœa but in routine surgery ritual purgation and strict withholding of fluids before operation may do just as much mischief Even enemata must be given with discretion Severe collapse sometimes resulting in death has followed administration of an enema in cases of colonic stases or Hirschsprung s disease

The younger the patient the more important is it to restore the body fluids to their normal proportions and when there is any urgency about the condition this is best done by infusion into a vein Absorption from the rectum is slow and sometimes the fluid is expelled into the bed an accident which might start a disastrous infection in any superficial lesion like a burn of the trunk Absorption from the subcutaneous tissues is also slow but can be relied on when the total volume of fluid to be introduced is small and veins are not easy to find *e g* a 6-lb baby suffering from pyloric stenosis The enzyme hyalase can be added to the fluid to break down tissue barriers and hasten absorption

If blood is to be given it should be grouped and cross matched as carefully as in the adult It is true that agglutinins are not present in formidable array and an infant may often be transfused with its mother s blood

the direction of the nutrient arteries in the limb bones, these are always directed away from the growing end of the bone and the mnemonic serves as a reminder also that if a child's arm is amputated above the elbow the stump will continue to grow, below the elbow it will not In the leg the opposite holds

The infant is insulated from its environment by a covering of fat which has its own characteristic distribution, and is often so thick and mobile as to conceal the bony landmarks The fat of the groin is surprisingly dense and vascular, and in the operation for hernia special attention should be given to hæmostasis, so that a hæmatoma does not form and provide a nidus for the infection which is always a local hazard

There are one or two points of importance to the anæsthetist The corneal reflex is absent during the first month or two of life Large tonsils and adenoids may make the passage of an intra-tracheal tube a tricky business The spinal cord at birth reaches to the level of the third lumbar vertebra, and is in danger if a puncture is made in the usual place

Physiology. The physiology of the infant differs markedly from that of the adult, and often in ways which concern the surgeon Perhaps the most noticeable is the more rapid respiratory rate, ranging from forty to the minute at birth to twenty-two to the minute at two years Respiration moreover is largely abdominal in type, the chest playing little apparent part in it It will be appreciated that operations on the abdominal wall may be very difficult under these conditions

The resting pulse of the newborn child will average 130 to 140 to the minute, falling to 120 in the first year, 110 in the second year and 100 in the third year It is therefore understandable that there is little cardiac reserve to cope with emergency shock and hæmorrhage

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during the first few weeks of life without mishap, but even so accidents are not unknown, and in any case it is undesirable to run the risk of setting up fresh incompatibilities which may prove pitfalls in years to come

Transfusion routes —

(1) Usually time is saved by exposing a vein from the start A forearm or wrist can be used, or the internal saphenous at the ankle, the danger of deep thrombosis not being great at this age

(2) The scalp veins or the internal jugular are sometimes prominent enough to be needled

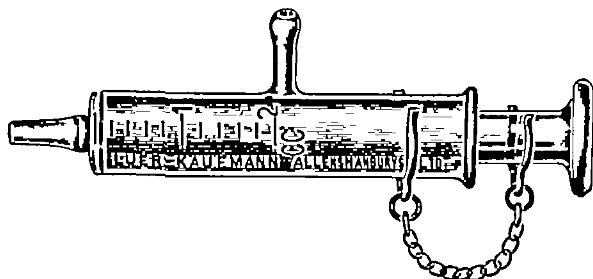


FIG 146 A Luer Kaufman syringe (*By courtesy of Allen & Hanbury Ltd*)

(3) Marrow transfusion is too slow to be of any help in an emergency

(4) Intra-muscular transfusion is effective as a hæmostatic only

Effective immobilisation is absolutely essential if the transfusion is to go off smoothly Nothing can be more annoying for the surgeon or bad for the patient than a transfusion which stops prematurely because the cannula has been tugged out of the vein by some chance movement Splinting should be so arranged that if there is to be any movement at all, limb, splint and tubing move together and not independently

A special set of instruments is needed for exposing and opening the vein, and the cannula should be of appropriate

dimensions Subsequent technique does not vary greatly from that employed in the adult but the rate at which the blood flows should be slower Ten drops a minute is a safe maintenance rate thirty drops a minute is a maximum urgent replacement rate this being equivalent to 100 ml an hour This will seldom be exceeded if a superficial vein is used no matter what the setting of the control In fact some form of positive pressure is often needed to maintain a flow at all A syringe of the Luer Kaufman type which has a side inlet connected to the reservoir often proves useful

Ten to fifteen millilitres per pound of body weight is sufficient blood to give an infant or young child at any one time unless there has been a recent severe loss For accuracy of measurement and as a safeguard against excessive dosage the blood should be delivered from a special graduated container and not from the ordinary bottle

Preparation for Operation Children are more likely than any other class of patient to find their way into the operating theatre with a full stomach but accidents are unlikely if nursing staff is on the alert and alive to the possibility

A basal narcotic is given before operation if the patient is over eighteen months

Seconal 04 grm per stone body weight

is simple and effective but there are many alternatives to choose from Transfer from bed to trolley should be made immediately the drug is administered to avoid disturbance later on It is essential that the child is asleep when it is wheeled from the ward to the anæsthetic room

A child s heat regulating centre is relatively unstable and responds readily to adverse stimuli The chest should therefore be covered in a woollen blanket or jacket

and the limbs clothed in cotton wool held in place by loose bandaging Electric blankets or hot-water bottles are an additional help when shock has developed, but may cause burns if not properly managed Theatre temperature should be maintained at slightly above the ordinary level at between 70°–75°

It is not unnecessary to mention that judgment must be exercised in all these matters Heat stroke can easily develop in a child undergoing an operation on a hot day if no allowance is made for weather conditions

Position on the Table. The Dennis Browne crucifix



FIG 147 A small child on an operating table is like a solitary pea on a dinner plate without some form of immobilisation This is a crucifix splint

enables an infant to be handled easily and prevents struggling during induction of anæsthesia Trunk and legs are secured to the vertical component of the splint and the arms to the cross piece This splint has the additional advantage that it maintains the correct relationship of head and arms Tugging on either when the other is fixed may lead to brachial plexus palsies

Local pressure from projections on the table, or by sandbags, or by allowing a limb to dangle, or by lithotomy poles, is another possible source of nerve injury When

sandbags are used they should be large enough to give support over a wide area. Padding the limbs with cotton wool as recommended above relieves the pressure on the deeper structures Here again it is important that nursing staff should be aware that a danger exists and that it is greater in young children because the natural coverings of their bodies give them less protection. Fortunately if the worst happens and a paralysis does develop it usually recovers completely

The Trendelenburg position is not well tolerated by children. In such operations as transplantation of ureters or an obturator neurectomy it should be used with discretion and the table restored to the horizontal as soon as the immediate need is passed A table with a lateral tilt is a distinct advantage for an exploration of hip or a thoracotomy By this device much sandbagging and moving of the patient may be avoided always an important consideration if the procedure is a trying one

Instruments It goes without saying that the instruments used in children s surgery should be appropriate to the task An attempt for instance to cut half way across a vein 1 mm in diameter with an ordinary pair of scissors is bound to end in failure Nevertheless the surgeon is not always able to obtain special equipment and he must content himself by being as selective as possible with what he has got

Certain instruments are by their nature and design traumatic and should be excluded altogether Others while admirable for their original purpose may be dangerous when misapplied—as an example toothed dissecting forceps used on soft tissues Few surgeons would deliberately pick up a piece of intestine or a large vein with this type of forceps but they are not infrequently employed to seize peritoneum or muscle which are just as delicate in structure It is good practice to put the toothed forceps



FIG 148 A drain improvised from a piece of salmon gut

well out of reach once skin and aponeurosis have been dealt with Kocher's forceps should be used with similar discretion

Crushing clamps have little place in children's surgery They cause œdema and necrosis, and are unnecessary

Intestinal clamps if used at all should be the lightest available with a good spring and protected with a rubber sheath

Artery forceps should be small with a fine point the mosquito type being best The aim should be to grasp the bleeding vessel and nothing else which is not possible with the larger types of forceps

Knives are usually of the Bard Parker type a No 10 blade being convenient in shape and size for general work with a No 15 for more delicate surgery

Instruments to serve a particular purpose are available at the choice and discretion of the surgeon

For wiping away blood stains cleaning blood vessels and similar structures a fragment of dental roll held in an artery forceps is most useful The dental roll is soft and absorbent and does not leave shreds in the wound as is apt to occur with surgical gauze

The diathermy cutting needle is seldom needed But the coagulating current provides a very satisfactory method of controlling multiple fine bleeding points especially in the neck where a bulk of retained catgut is undesirable It should not however be relied on for vessels of any consequence

All drains should be soft and pliable A convenient drain for small wounds can be improvised by gripping the ends of two or three pieces of salmon gut in a couple of pairs of artery forceps and twisting these in opposite directions The centre of the strand is then seized by a third pair of artery forceps and the two end pairs allowed to drop It will be found that the two halves rotate round each other and retain the twist A drain of this kind is remarkably efficient in the neck and leaves no distortion of the scar

Ligatures and Sutures Ligatures and sutures differ little from those used in adult surgery Material and size

are at the choice of the individual operator, though he will naturally be biased towards the finer and more pliable varieties Bulky ligatures and sutures are not suited to the smaller-sized artery forceps and needles which are employed in these little wounds

Technique. Speed and precision are essential to the surgeon who operates on the young The child's metabolism is easily upset and, for reasons already given, shock supervenes rapidly There is therefore no place for a hesitant fumbling approach or excessive deliberation

In certain branches of surgery, notably in plastic and neuro-surgery, a slow, painstaking technique has been developed, so that operating time is prolonged and may extend to several hours Such a system is dangerous when dealing with children

Operations which take a long time are better avoided or split up into stages Otherwise mortality will be high The surgeon who finds that he must resect bowel in a case of intussusception must realise that there is only a 50 per cent chance of the patient surviving In the abdomen, particularly, whatever is necessary must be done as simply and speedily as possible

The second principle of pædiatric surgery is one which is implicit in the nature of the work—gentleness at all times and with all tissues Rough handling leads to tearing, bruising, hæmatoma formation, and œdema with consequent shock, pain, liability to sepsis, and delayed healing, no matter what the age of the victim, but in children the harm done is magnified a hundred-fold by the fragile delicacy of the parts

Sharp dissection should be the aim of the operator Clean division of the tissues causes less shock than tearing them apart by blunt dissection which leads to fraying, œdema and extravasation of blood There are, of course, times when anatomical details are distorted, or when

inflammation or growth have obliterated landmarks so that vital structures are in danger of being injured Here prudence may dictate an attempt to define these structures with a piece of gauze or dental roll grasped in an artery forceps but normal methods should be resumed as soon as the position becomes clear Bruising of tissue is one of the prime causes of minor sepsis and delayed healing in wounds

The skin is closed by any of the usual methods Michel clips are quick and clean but are not always easy to remove painlessly A continuous skin suture is often advocated because it seals the wound more effectively against infection for the first forty eight hours Whatever method is used the essential points are accurate coaptation of edges always and lack of tension

Wound Infection A certain amount of superficial wound infection is if not inevitable at least not surprising in this branch of surgery The inability of young children to keep themselves clean their restlessness and tendency to roam about the cot so that dressings become displaced together with incontinence of urine and fæces all set a problem for the nursing staff charged with the care of the wound Incisions round the lower abdomen and groin are of course especially liable to contamination

Measures to limit wound infection are merely an extension of normal antiseptic precautions Skin toilet is important The child s skin especially those parts in operation areas is perhaps not commonly washed as thoroughly and regularly as in the adult and is in addition extremely tender and sensitive especially to chemical irritants such as iodine or mercury Such irritants may inflict severe burns on an area already subjected to a protracted and unaccustomed vigorous cleansing

Skin which has been washed and surgically cleansed with an antiseptic will remain clean for a short time only



FIG 119 The unruly member is excluded from the field of operation by wrapping it in a swab

Organisms are rapidly brought to the surface again from sweat and sebaceous glands There is, therefore, every reason for cleaning the operation field again in the theatre and drying it with an application of spirit Such a routine is efficient and harmless

Wound towels applied in such a way that they protect the subcutaneous fat, a tissue most susceptible to infection, should be used in all but the most trivial procedures

Unabsorbable sutures and ligatures appear to be poorly tolerated in fat and subcutaneous tissue and are a common cause of minor sepsis in wounds, the sepsis clearing rapidly after the extrusion of a fragment of the foreign body This must not weigh, however, against the use of such ligatures where necessary

In cases where infection seems likely, as in delivering a gangrenous appendix or an infected gland, the muscle and fat may be dusted with a bacteriostatic powder such as a penicillin and sulphathiazole powder from an insufflator, and a salmon gut drain inserted for twenty-four hours

After operation, clean wounds are sealed, covered in strapping and left alone This closed dressing offers several advantages The child cannot get at the wound, there is no need for repeated unpleasant dressings, and

the risk of contamination at such dressings is avoided. The disadvantage is that the wound cannot be observed and the temperature chart may give the first indication that all is not well Further some children s skin will not tolerate strapping an ugly pustular rash developing in a matter of hours In such a case the wound may conveniently be protected by a plastic dressing like Nobecutane applied either in solution or by spray But such an application must never be used over a potentially infected wound

Napkins are a problem to which there is no adequate solution other than unremitting attention by the nursing staff and an unlimited supply of linen In wounds in the napkin area it is probably as well to leave the napkin untied and risk a dirty bed rather than have a urine-soaked towel tied round the part

CHAPTER XX

TACTICS

Anatomy and the Surgeon An anatomical diagram or even a dissected specimen is a poor imitation of the living, bleeding tissues of the body, surgical anatomy being a very different thing from dissecting room anatomy, almost as different as if it possessed an additional dimension

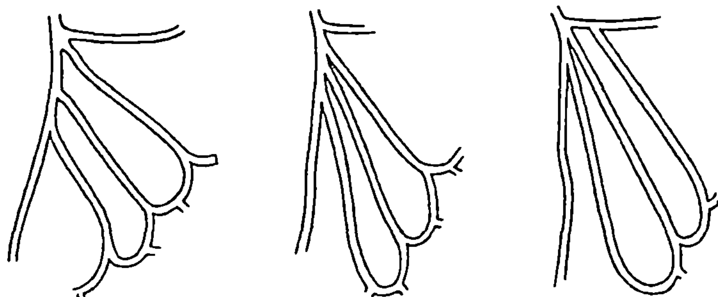


FIG 150 Vagaries of the sigmoid arteries

Even in the relationship of the structures to each other there is a distinction to be drawn between the two The anatomist's usual anxiety is to demonstrate what should be there the surgeon is forced to accept what is there This is important because anatomical variations are constantly cropping up An abnormal obturator artery occurs in 20 per cent , the arrangement of the gall bladder with its ducts corresponds to " normal " in only one case out of four , the vagaries of the sympathetic have foiled the physiologist for years These eccentricities are puzzling enough in themselves without taking into account the distortion caused by disease A combination of the two is certain to defeat a surgeon who works by rule of thumb

Not only does the arrangement of the structures vary

from subject to subject but so do the structures them selves There is all the difference in the world between the elastic skin of youth and the baggy coverings of senility The subcutaneous fat of a robust man bears little resemblance to the same layer in a visceroptotic woman in the man the fat is firm and granular in the woman it is sparse and mobile Even in the same individual fat in one part of the body is quite different from fat in another One man s arteries are resilient and contract when cut another s are like lengths of clay pipe A sheet of fascia sometimes forms a substantial barrier that is easily recognisable at operation but often it is scarcely distinguishable from the surrounding areola.

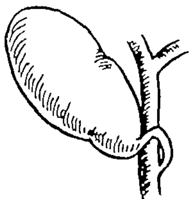


FIG 151 A vagary of the cystic duct.

Allowance must be made for all this diversity when handling the parts and still more when repairing them Suturing methods and materials must be suited to the particular case that is being dealt with

In old age or in a subject wasted by cancer there is a temptation to use a thicker catgut and more of it than usual but this only throws an additional burthen on tissues that are ill fitted to bear it A suture with a greater tensile strength than the structures it unites never serves any good purpose and if it has any irritant properties may do positive harm It is wiser therefore to rely on occasional non absorbable sutures to take the main strain in this type of wound and avoid the bulkier kinds of catgut altogether Perhaps with the subconscious idea of compensating for nature s weakness one is



FIG 152 Tension—dissecting the axilla



FIG 153 Tension—lifting the skin away from the underlying structures while an incision is deepened, *e g*, for ligature of the saphenous vein

inclined in these cases to pull the sutures tighter than ever This is also a mistake because it is bound to have a bad effect on the blood supply to the edges of the incision, and if blood supply is diminished healing is bound to be

interfered with Interrupted sutures are always kinder to the blood supply than a continuous and for this as well as other reasons they are preferable where there is a danger of disruption

If the vessels are clay pipe and their mouths gape open in the wound the ordinary constrictor mechanism is out of action and more than usual care must be given to hæmostasis This class of patient may well have a raised blood pressure which increases the risk of post operative hæmorrhage from any bleeding point that escapes attention at the time of operation

Mikulicz gave the palm to the surgeon who knew how to sew up It may well be that he was thinking of a nice discrimination in such matters as these when he pronounced judgment

In Praise of Tension Anatomy ante- or post mortem is designed to economise space Everything is packed into the smallest possible compass Even the great serous cavities are potential and do not really exist unless they are distended by fluid or air It follows from this that the tissues must be kept constantly on the stretch if the surgeon is to have any chance of seeing what he is doing Tension therefore is a most necessary adjunct to dissection Without it the parts lie in a confused muddle and the task of disentangling them becomes almost impossible

Tension tautens structures so that they offer resistance to the knife and can be deliberately divided or deliberately avoided retracts a divided structure and automatically reveals the structure underneath often reveals a bleeding point that might otherwise be missed in other cases controls hæmorrhage and prevents flooding of the field and unnecessary loss of blood renders membranes translucent and reveals the position of vessels coursing across them opens up planes of cleavage But with all these

advantages tension has its drawbacks Even when not overdone it causes distortion Structures are dragged out of position, and may fall victim to knife or ligature in consequence Examples are given in Fig 154 The danger is often greatest in the straightforward case in which everything " comes up easily "

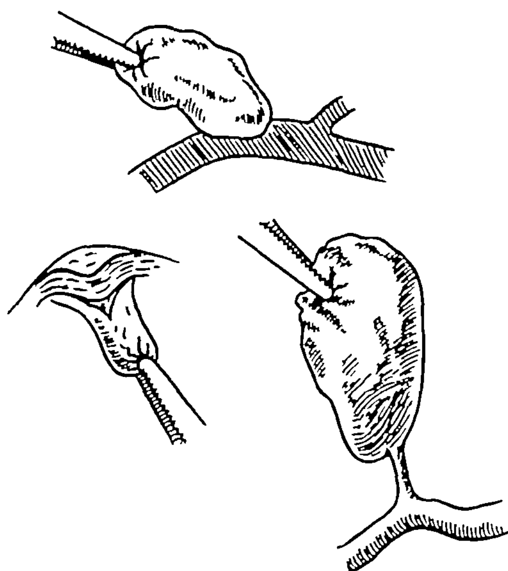


FIG 154 Dangers of tension—tension on a branchial cyst may drag on the internal jugular vein, tension on a pile may drag on the sphincter, tension on the gall bladder may drag on the common bile duct

And tension may conceal vessels instead of revealing them

Case Note In clearing the pedicle of the kidney a strand of what appeared to be fascia was seen entering the hilum A nick with the scissors showed that it was a renal vein

Even a large vein empties itself and collapses into a ribbon when it is pulled upon in this way If it is partly divided and the incision gapes air may be sucked into the lumen with grave results for the patient

These dangers accompany even a moderate degree of tension They can be avoided by exercising a little foresight

and care Excessive tension *is* another matter It inevitably causes local trauma and very often general shock as well

Dissection In a difficult dissection a knife is a safer instrument to use than a pair of scissors There is a feel in the point of a knife that is entirely lacking between the blades of a pair of scissors Altered resistance is sensed by one but not by the other Where anatomical details are ambiguous scissors should be reserved for snipping

Blunt dissection is equally undesirable in such cases It may answer well enough when there are no dense adhesions and planes open up readily but amongst fibrosed tissues it does much more harm than a clean cut Sometimes however the confusion is so great that the surgeon dare not bring a sharp instrument anywhere near the danger zone for fear of damaging an important structure In these circumstances it is not a bad plan for him to make *a deliberate dissection of all the structures concerned as a preliminary to the business in hand*

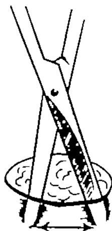


FIG 155 A pair of scissors used in reverse for blunt dissection.

Thus the ureter is exposed before an abdomino-perineal resection of the rectum the hepatic cystic and common bile ducts before a cholecystectomy and the femoral vein above and below the point where the internal saphenous joins it before a ligation of the latter Then with the important structures identified and laid aside there is no further need for careful separation or finger stripping the knife can cut boldly and widely through the surrounding tissues no matter how matted they may be In this way time is saved by what at first appears to be rather a roundabout method of procedure

Dissection through scar may be as tedious as anything in surgery, but there is sometimes consolation towards the end of the task The structures often prove to be more encased than incorporated in fibrous tissue, with the result that they separate fairly easily from their bed once they are defined (see also Chapter XVIII)

Even in the absence of disease, structures are often



FIG 156 Stripping tissue with the angle of a pair of scissors

closely adherent to each other The anterior tibial muscles, for instance, appear to be fused into one mass in the upper part of the leg, and it is quite difficult to find a way between them in order to ligature the artery But their tendons are easily defined below, and if the separation is started here and continued upwards the operation is greatly simplified A general principle can be deduced from this —

> *Always begin if possible a dissection where the structures are separate*

This principle has already been mentioned in connection

with the surgery of cut tendons It can be applied to many other fields of which two are mentioned here to illustrate its universality In operating on a recurrent hernia it is sometimes quite difficult to isolate the cord This can be done easily if it is picked up just below the pubis where it has never been interfered with and is not adherent and then dissected free from its surroundings in a proximal direction At the start of a gastrectomy difficulty often arises in finding a way into the lesser sac through the gastro-colic omentum This difficulty can be avoided by starting well to the left on the lesser curvature where the sac is potentially much deeper than it is on the right and the stomach can be lifted right away from the pancreas.

Natural Planes As has been said the natural planes of the body may be concealed by disease but are seldom completely obliterated and once the right one is discovered the surgeon s difficulties usually diminish or disappear Sometimes indeed dissection becomes superfluous and gauze stripping is all that is required to separate the parts Even hæmorrhage comes to an end because the plane is largely avascular and any vessels that do cross it can be seen and picked up before they are divided It is only when the plane is lost that the business again becomes a labour For instance a fibrotic gall bladder can commonly be stripped off its bed in the liver by the tip of the index finger once the peritoneal reflection between the two is divided and the process is accompanied by only a small amount of bleeding so long as the finger tip does not

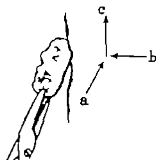


Fig 157 Tonsillectomy (a) is the dissecting force, (b) is the resistance of the pharyngeal wall ( ) is the resulting force which strips the tonsil from its bed.

wander off the track and burrow into the liver itself Similarly with dissection of the tonsil In both cases, however, there is a right and a wrong way to do the stripping The more resistant structure should be wiped off the less and not the other way round, that is to say the liver must be wiped off the gall bladder and the pharyngeal wall off the tonsil Stamp collectors will appreciate the

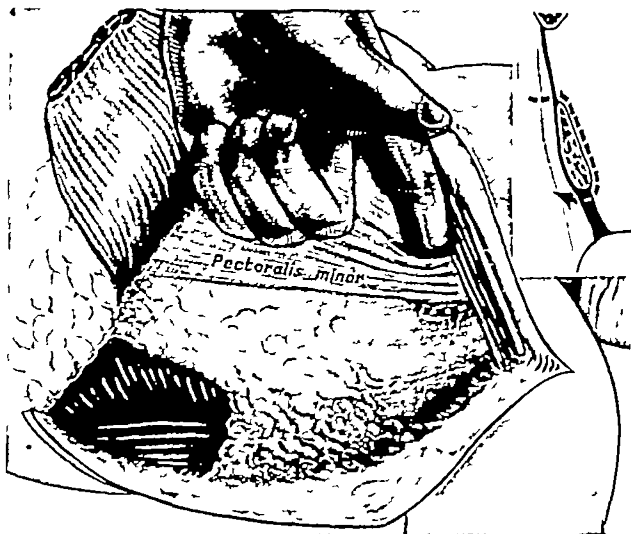


FIG 157A Dissection of the axilla A finger passed under the muscle puts it on the stretch while it is being divided, at the same time protecting the structures underneath (*By courtesy of Mr Victor Riddel and the "British Journal of Surgery," John Wright and Son Ltd*)

importance of the distinction The principle is illustrated in Fig 157 by representing the procedure as a triangle of forces

Nowhere are the advantages of following tissue planes more apparent than in the removal of an innocent tumour To deliver a lipoma in this way has been described as "one of the most pleasing operations in the whole of surgery" Unfortunately a fallacy has arisen over the

business The plane of separation lies between the tumour and the capsule not between the capsule and the surrounding tissues The capsule in fact belongs to the surrounding tissues of which it is a condensation When therefore the surgeon is advised to enucleate a mixed parotid tumour intact within its capsule he is being asked

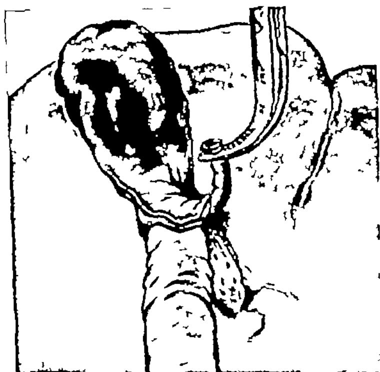


FIG 138 Stripping the gall bladder from its bed.

to do the impossible He must resect part of the parotid gland or perhaps the whole of it if he wants to make certain of leaving no neoplastic cells behind.

Use of the Fingers and Hands The advocate of the no-touch technique sees no reason why the surgeon s fingers should ever come into contact with the patient s

tissues He would use instruments for everything—dissecting forceps for holding swabs, artery forceps for tying knots, and never anything but a knife for dissection The arguments for and against such an attitude are discussed in another chapter It is sufficient to say here that the surgeon who adopts it wholeheartedly must be content to work without the sense of touch This may be a considerable deprivation No one will deny that it is often a great deal easier to find the right path with the fingers than with the knife An illustrative example—the stripping of the gall bladder from its bed—has just been given For this a sharp instrument would serve almost as well because the stripping is carried out under vision, but there are times when a viscus or tumour must be mobilised blindly, as, for instance, in the enucleation of a prostatic adenoma Here anything like sharp dissection would be entirely out of place The finger finds the path of least resistance and follows it in a way that would be quite impossible with a knife So also with many other encapsulated tumours or cysts

When it is a matter of exploration the sense of touch can hardly be dispensed with A hand slipped through a laparotomy incision will discover an abdominal tumour with an ease and certainty that no endoscope can rival A finger will find a foreign body that a probe might easily overlook, or break a way into a deep-seated abscess when a sinus forceps might go astray And yet it is astonishing what the fingers can miss Fig 159 is a pyelogram showing a stone in the kidney which was quite impalpable when the organ was exposed Even the thin-walled gall bladder or common bile duct have a surprising capacity for concealment

Again, in the business of maintaining exposure, the fingers or hand can sometimes replace a retractor with advantage There is no doubt that heavy retractors,

especially if they are of a mechanical variety can do a great deal of harm The hand of an assistant adjusts itself to the changing needs of the operation in a way that a self retaining retractor never does In some cases



FIG. 159. The stone in the lower calyx could not be felt even with the kidney delivered on the loin

nothing but the hand is capable of doing the work Take as an example the operation of choledochotomy—what else but an outspread hand could hold stomach and duodenum back so that the common bile duct is exposed and accessible?

It follows then from what has been said here and elsewhere that though the risks of infection may be less if the fingers are kept out of the wound the added safety may be purchased at too high a price The wise surgeon will

not deny himself the use of one of his five senses when the need arises Seeing is believing, but feeling is God's truth

Technique Varies Naturally, liberties of this kind may be taken more readily in some types of surgery than others, in abdominal surgery than in joint surgery, for instance Indeed, technique generally must vary greatly according to the kind of work that is being done, so much so that one surgeon's methods may astonish and alarm another who is accustomed to operate in some different part of the body

The fact is that there is too much to be known about the various branches of surgery for any one man to familiarise himself with the lot Even " general " surgery tends to split itself into compartments, and the highest degree of skill is usually developed by the operator who selects one or two of these and confines himself to them So the novice is well advised to decide early in his career what type of surgery he is best suited for, and devote more and more of his attention to it " In brief, sir, study what you most affect " , persevere with the particular branch you have chosen until the work becomes repetitive and therefore easy for yourself, your assistant, and your theatre staff

CHAPTER XXI

THE ASSISTANT

THE law now recognises the assistant s responsibility and may hold him to account for anything that goes wrong in his sphere during the course of an operation His chief certainly will so hold him and perhaps in a fashion that he is unlikely to forget for the remainder of his career On the other hand an efficient assistant recommends himself in a way that is least likely to be overlooked or go unrewarded

> The assistant at an operation must possess the habit of attention if he does not his thoughts are sure to be far away at the critical moment when his help is needed
>
> C B Lockwood

No matter how boring the procedure may become the assistant must not allow his interest to wander Perhaps one of the surest ways he has of maintaining it is to imagine he is performing the operation himself by so doing he will certainly improve his chances of foreseeing the surgeon s needs and supplying them without hesitation or delay

Preparation At the start the assistant should see that the patient is correctly placed on the table that the towels are removed without soiling the prepared area that the skin is painted with the appropriate antiseptic and that the sterile sheets are correctly draped These details all require supervision and it is the assistant not the principal, who should exercise it

Hæmostasis Once the incision is made hæmorrhage is more or less continuous It is the assistant s task to

not deny himself the use of one of his five senses when the need arises. Seeing is believing, but feeling is God's truth

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assistant joins in the efforts to pick it up instead of quietly maintaining the exposure the chances are that it will evade capture all the longer

When a bleeding point is secured it must be tied off Here again the assistant should give place to the surgeon If he always does this he can never be held responsible



FIG. 161 When two bleeding points are tied with the same ligature the forceps should be held dead in line otherwise the beak of one or other forceps may be included.

for a slipped ligature But he can contribute greatly to the ease and success of the tying off by —

(*a*) Taking the uppermost forceps first

(*b*) Holding the forceps in such a way that the surgeon s hands move backwards and forwards in tying the knots and not from side to side

(*c*) Depressing the handle and elevating the point of the forceps so that the ligature falls easily into place

(*d*) Maintaining full exposure until the second hitch of each knot is secure and if necessary not releasing the forceps until it has fallen into place

prevent it from obscuring the field, and help the surgeon to pick up the bleeding points responsible for it

He has a choice of two methods—suction and swabbing Of these suction is cleaner and less traumatic, and involves no risk of leaving anything in the wound Unfortunately it is not so efficient as swabbing Few mechanical suckers will cope with heavy bleeding or remove blood that has started to congeal The swab is therefore more popular

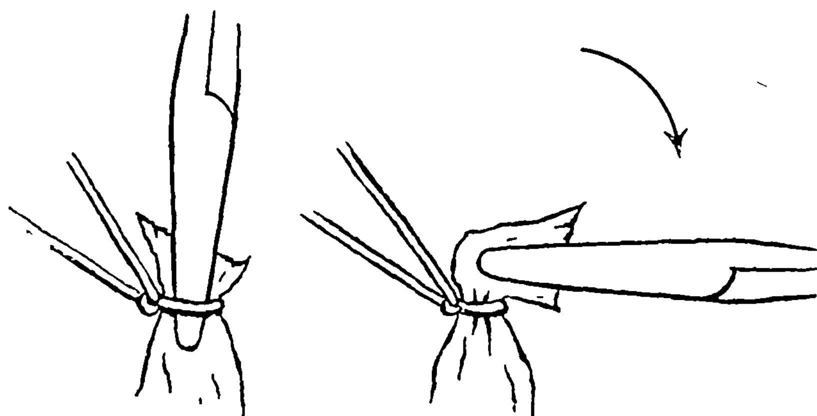


FIG 160 If an artery forceps is held vertically while a ligature is being tied, the beak of the forceps may be included, with the result that the ligature slips, either at once or, worse still, when the patient is back in bed This does not happen when the forceps is held horizontally

It should be used to blot and not to wipe, and it should be applied and removed quickly "There and away" is all that is required to give the surgeon a chance of applying his Spencer-Wells For more delicate work, where it is not so much a question of stopping hæmorrhage as of maintaining a clear field, the sucker comes into its own, fitted with a fine nozzle it is much in favour with plastic surgeons

In the long run time is saved by a strict division of labour The surgeon should be left to do all the picking up This rule holds good even when a considerable vessel is divided and the hæmorrhage is alarming If the

But in most cases a retractor must be used Now holding a retractor for any length of time can become quite a boring business especially when it is difficult to get a view of what is going on Nevertheless the necessity is there and it must be met If the handle of the instrument is held a little above the horizontal (with due care that its flange does no mischief by pressure on vessels or viscera) the tendency to slip will be less but real safety depends only on assiduity Even when something else demands urgent attention retraction must never be abandoned For example—a large vessel comes in the way of the knife the field fills up with blood and the *anæsthetist feels for the patient s pulse If the assistant* drops his retractor at this stage and looks for an artery forceps in order to stop the hæmorrhage the result will be that neither he nor the surgeon can see what is happening in the wound How much better it would have been if he had preserved his sang froid and *maintained the exposure*

Tension comes next in importance to exposure Tension steadies the structures operated on and what is more important separates them from each other so that their relationships are revealed and the surgeon can see his way clearly to his objective Without proper tension the difficulties of dissection in the living body are multiplied a hundredfold

It sometimes happens that packs or swabs must be placed inside the abdomen to control the intestines and keep them away from the field of operation Most packs have a length of tape attached at one corner to the end of which the assistant should attach a Spencer Wells when they are employed in this way In any case he should not fail to make a mental note of the number of packs used The onus of counting them does not rest on him but there can never be too many people on the alert against the risk of any oversight in a matter like this

(*e*) Cutting the ligature leaving the ends neither too short nor too long, obviously the greater margin of safety given by longer ends will be required when a larger vessel is being tied -

The reason for (*a*) is to clear the field for tying the deeper and more difficult ligatures The reason for (*b*) is given in the chapter on knots Anyone who has noticed how often ligatures go astray because the exposure fails when the hæmostat is taken off after the first hitch of the knot is tightened will not question the importance of (*d*) There is a right and a wrong way of cutting a ligature with a pair of scissors The cut should be made with the end of the scissors, this ensures that no other structure is included between the blades, an accident that may occur if the cut is made near the angle And the cut should be made with the blades at right angles to the ligature, even the sharpest pair of scissors will gib at cutting sideways

Most assistants are accustomed to release the Spencer-Wells with the left hand and cut the ligature with the right Certainly it is a good thing to be able to reverse the hands when necessary, and release with the right before cutting with the left, but not everyone is ambidexterous, and the assistant who wishes to cut ligatures with his left hand should be very well practised indeed before he attempts to show his skill in the operating theatre

Exposure First, last, and all the time the assistant must maintain exposure All his other duties give precedence to this If, in fulfilling it, a retractor can be dispensed with, so much the better for the patient Quite often the gentle pressure of a hand is all that is required, perhaps aided by a moist pack in the abdomen, to protect the viscera, and prevent them from eluding the gloved fingers

got rid of as soon as possible preferably with the sucker they may be sterile but they are irritant to the tissues if allowed to remain in contact with them for long In the already grossly infected case—the abscess for drainage—the fact that pus is bound to drain through the wound is no excuse for slovenliness a careful arrangement of packs and a thorough initial emptying will at least help to minimise contamination

The laws of asepsis may be infringed in so many ways that it is useless to multiply examples Safety lies only in constant vigilance on the part of everyone in the theatre and more especially of those whose knowledge of bacteriology should make them aware of the dangers

Care of Sutures A continuous suture is a perpetual source of trouble unless it is kept under control The slack is only too likely to get in the surgeon s way if it

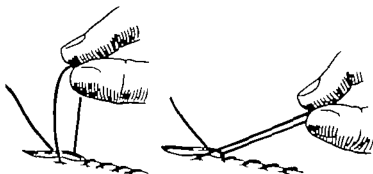


FIG 162A. The assistant follows a suture line—correct, incorrect.

hangs loose and if it is kept clear of the wound it may still foul the handles of a clamp or become contaminated from contact with the bare skin These accidents will not occur if the packs used to isolate the anastomosis completely cover the handles of the clamps and the skin towels are never allowed to ruck up or come adrift A suture should never be picked up by anything but the fingers or a special holder an ordinary Spencer Wells or

Prevention of Infection It is an important part of the assistant's business to be on the watch for any kind of carelessness that might lead to infection Even in a "clean" case the risk of contamination from the skin can never be absolutely eliminated, but it can be reduced to a minimum if wound towels are correctly adjusted and kept in their proper place from beginning to end of the operation In a "dirty" case the danger is much greater



FIG 162 A forceps is automatically clipped on the tape of any pack that is placed inside the abdomen

While bowel is being anastomosed, for instance, it is impossible to preserve asepsis But gross soiling can be prevented if the area is completely isolated by packs at the start, escape of intestinal contents is anticipated and prevented, and all instruments, etc , used during procedure are put aside when it is complete and not allowed to appear again before being resterilised These precautions are seldom overlooked, but it is not an uncommon thing to see the bowl of saline in which packs are wrung out unchanged from start to finish Naturally it soon becomes a reservoir of infection

All discharges—biliary, urinary, intestinal—are better

neglected—should always be applied to its extreme end With two-layer intestinal anastomosis there may be some confusion between these forceps and it is a good practice to select a larger pair for the stronger suture *i e* the all coats so that no mistake is made at the finish and each suture is knotted to its own end

Prevention of Shock As with infection so with shock it is the assistant s job to let nothing escape his notice that might contribute to it Some degree of shock is inevitable after any big operation but there are many ways in which it can be minimised All exposed tissues can be kept covered with hot packs to preserve their natural moisture and prevent loss of heat The intestines can be protected in the same way but the abdominal wall is kinder to them than any pack or towel and whenever possible they should be kept inside it if a loop of intestine is left outside the abdomen for any length of time it dilates from lack of support and this may start an ileus

When there is any delay in picking up a bleeding vessel the hæmorrhage from it can often be stayed by direct or proximal pressure until the times comes to deal with it in a more permanent fashion On the other hand if the sucker is relied on to keep the field clean hæmorrhage will be encouraged rather than stopped A considerable quantity of blood can be saved during the course of an operation by attention to such details That this economy is well worth while is suggested by recent estimates of average blood loss in everyday surgery—always more than is suspected—two-thirds of a pint in gastrectomy thyroidectomy and radical mastectomy and more than two pints in lung cases the amount being invariably greater when there is oozing from the separation of adhesions

Avoidance of trauma rests largely with the operator but an assistant can often help by relieving strain *e g*

a toothed dissecting forceps will cause dangerous fraying which may lead to rupture later on For the same reason

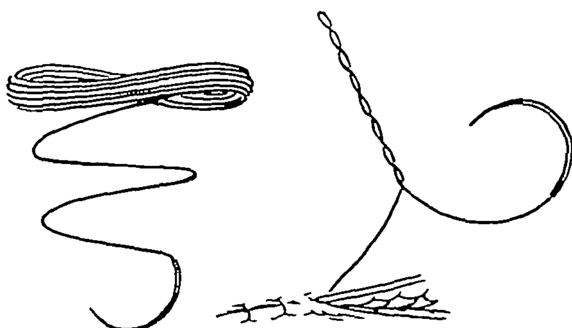


Fig 162B If catgut is ripped off its bobbin in this fashion it will cockle in use It should be deliberately unwound



Fig 163 During the anastomosis of bowel the handles of the clamps should always be covered, otherwise they will almost certainly snare the slack of the suture line

a Spencer-Wells used to keep the end of a suture line or stitch out of the way until the time comes for cutting it or knotting it off a precaution that should never be

in use throughout the operation Infection may easily be introduced between the edges of the wound by this manœuvre In any case the dampness is undesirable If blood stains must be got rid of it should be done with a fresh detergent After that the final coat of antiseptic should be applied with the same care as the first

Bandaging is usually left to the nursing staff but there are occasions when carelessness at this stage may mar the whole operation If for instance a dressing on a skin graft comes adrift the graft will probably die If the pressure on a knee after meniscectomy is inadequate the joint will fill up with fluid If the lateral flap after a mastectomy is not pressed well home serum will collect in the axilla and have to be evacuated later on These are cases then when a little extra care at the finish may make all the difference between a good and bad result to the operation

The Notes Probably the best way of recording the details of an operation is for a surgeon to dictate as he goes along As this method is seldom practicable the job usually falls to the house surgeon who may be inclined in the hurry and bustle of an operating list to postpone it to the next day It is very doubtful whether it is feasible to write an accurate account so long after the event especially when several major operations have been performed Every effort should be made to put on paper at least the main facts as quickly as possible They can be elaborated later and even if they are not they will often provide all the information that is required

To Summarise We have seen that the more closely the assistant identifies himself with the operation the quicker he will be in anticipating the wishes of the person who is performing it The most imperative of these will always be a clear and uninterrupted view of the operating field. Hence the importance of painstaking retraction

relaxing the drag on the stomach during a high gastrectomy, easing pull on the mesentery, and refraining from unnecessary retraction of the abdominal wall (it is not unusual to see one assistant doing his best to counteract the efforts of the other by tugging against him as hard as he can)

Saving Time. A surgeon needs at least two pairs of hands if he is to do his job properly Fortunately, the additional pair is usually at his disposal, although they belong to someone else But delay inevitably results from the dual control unless the assistant can train himself to think ahead and anticipate what will be wanted next In surgical clinics abroad, where a team works together for years on end, the need for anticipation is not so great, each member of the team *knows* what will be wanted next Perhaps this is the only way to get real efficiency

The least experienced assistant can, however, save time automatically by keeping the equipment in order A surgeon should be able to pick up the instrument he needs without having to search for it amongst a whole jumble of others, and he should certainly not have to wait for it because the assistant has appropriated it to his own side of the table Scalpel, dissecting forceps, a pair of scissors, and a few pairs of Spencer-Wells, are in constant demand, and they should always lie ready on the sheet with handles pointing in the right direction Other instruments can be produced on request, and cleared away once they are done with There is no excuse for leaving a litter of things that are no longer required scattered about the operating field

The Dressings The assistant should see to it that asepsis is maintained to the very end when the dressing is *securely* in position It is not unusual for the edges of the wound to be "cleaned up" at the last moment with a swab moistened in a bowl of saline or water that has been

CHAPTER XXII

TRANSFUSION AND INFUSION

It appears that shock cannot be explained away in any simple straightforward fashion Primary shock is understandable enough as a reflex nervous phenomenon The boxer who receives a punch in the pit of the abdomen collapses at once An anæsthetist watching a patient during an operation quickly notices that something is wrong when the surgeon starts to mishandle the testis or tug on the mesentery In these cases cause and effect are closely linked and when the cause ceases to operate the effect wears off—the boxer recovers the patient s pulse comes back to normal But secondary shock with its delayed and often insidious onset is a very different business

Case Note A radical breast operation was completed in under an hour with very little loss of blood and the patient left the theatre in excellent condition An hour and a half later a message came from the ward that the woman was in a desperate state. Two pints of blood had to be pumped into a vein before the pulse again became perceptible at the wrist

One is reminded of the story of the burnt medical officer related in another chapter In both cases the latent period the deceptive interval was astonishingly long No nervous reflex could have such a slow action Some poison must have been accumulating in the blood until it reached a sufficient concentration to upset the normal arrangements of the vascular system

We are told that in hæmatogenic shock the blood volume is always diminished and indeed this can be

and constant care to keep the field clear of blood This last will contribute to the welfare of the patient if it is achieved by checking the bleeding instead of merely mopping up the blood The assistant's next consideration must be for all those details which the surgeon is too occupied to attend to Chief among these are prevention of any infringement of the aseptic ritual, and avoidance of anything that might predispose to shock Throughout, watch must be kept to preserve order and tidiness in all the equipment being used At the finish the dressings need to be supervised Finally all specimens should be correctly labelled and the appropriate forms completed before they are dispatched to the laboratory And an account of the whole matter should be written down while its particulars are still fresh in the mind

During a routine operation the three most important shock producing factors are —

(1) Hæmorrhage.
(2) Trauma
(3) Prolonged or stormy anæsthesia

The surgeon who is careful in his technique who avoids unnecessary exposure of raw surfaces who above all never pulls or hauls on viscera ought rarely to shock his patient And he will not do so if he has an anæsthetist who is prepared to start treatment at the first sign of danger Unfortunately as has been seen shock is a condition which does not announce itself straightaway There may be a significant delay between the onset and the appearance of the first sign which means that a corresponding delay in starting treatment is inevitable For this reason it has become the practice in certain centres to give a pint or two of blood as a routine to every major abdominal case It is claimed that the mortality over a period is thereby notably diminished.

Signs of Shock For our purpose the stages of shock can be represented as —

Diminished blood volume from whatever cause.
Compensatory vaso-constriction
Stasis
Circulatory collapse
Tissue anoxæmia
Death

Hæmo-concentration of course plays a part by increasing the viscosity of the blood but it is not a factor for the surgeon to worry about in the middle of an operation He or rather the anæsthetist must look to clinical signs for guidance.

proved quite conclusively in the laboratory After hæmorrhage it is a natural and likely consequence How did it come about in these two cases? In burns, it is true, there is always weeping from the burnt surface and exudation into the surrounding tissues, but this will not drain enough plasma off the blood vessels to bring the circulation to a standstill

During the mastectomy operation referred to above hæmorrhage was minimal, and there was no subsequent loss Nevertheless profound shock developed in the ward The text-books account for the mystery by saying that anoxia alters the permeability of the capillary walls and plasma escapes into the deeper tissues of the body No one, however, has been able to demonstrate œdema of muscle or viscera on these occasions Whatever the explanation the fact remains that in this type of shock part of the blood fluids disappear

Causes of Shock. The causes of the condition are protean To the layman the word shock suggests emotional upheaval, and there is no question that anxiety and fear can contribute very considerably to surgical shock Under war conditions physical exhaustion, dehydration and toxæmia are other antecedents But shock should rarely be seen in routine work It ought nearly always be possible to " make the patient fit for surgery " beforehand, as Lord Moynihan felicitously phrased it The accident case can be resuscitated The case in which there has been considerable fluid loss—by vomiting, by fistula from the bowel or biliary tract, by prolonged suction through a Ryle's tube—can be restored with an intravenous glucose solution The debilitated case can be built up with transfusion (no patient should be allowed to go to the theatre with a blood pressure under a hundred or a hæmoglobin under seventy-five unless the operation is to stop hæmorrhage

But by and large it can be said that if the pulse rises above 100 or the blood pressure drops below 100 without obvious cause the anæsthetist should begin treatment alterations in pulse and blood pressure associated with some passing difficulty in the operation need not be taken so seriously If the pulse rises to 140 or the blood pressure drops to 70 the anæsthetist should warn the surgeon and if the pulse rises further to 160 and the blood pressure drops to 60 he should advise that the operation be discontinued when this is in any way possible These indications will be accompanied by more obvious ones—pallor sweating maintenance of anæsthesia on a steadily diminishing dose—but the pulse and still more the blood pressure are the main standbys in diagnosis During every big operation a stethoscope and sphygmomanometer with distant controls should be strapped to the patient s arm

It will be noticed that blood pressures over 100 are ignored in the table A normal blood pressure of 140 may drop to 120 or even 110 under anæsthesia without detriment to the patient A moderate fall of this order is quite natural and in fact desirable because it lessens the tendency to hæmorrhage.

Nature has certain defence mechanisms notably vasoconstriction which compensate for the initial diminution in blood volume and it is not until these begin to fail that the pulse starts to rise and the blood pressure to drop Herein lies the explanation of the anæsthetist s failure to make an early diagnosis No great harm results from his tardiness if he wastes no time in starting treatment when the pulse does begin to quicken but if there is still further delay the patient s condition is likely to deteriorate quite rapidly Severe and prolonged shock produces changes in heart brain and kidneys which often prove irreversible

Blood Grouping Up to a few years ago it was only

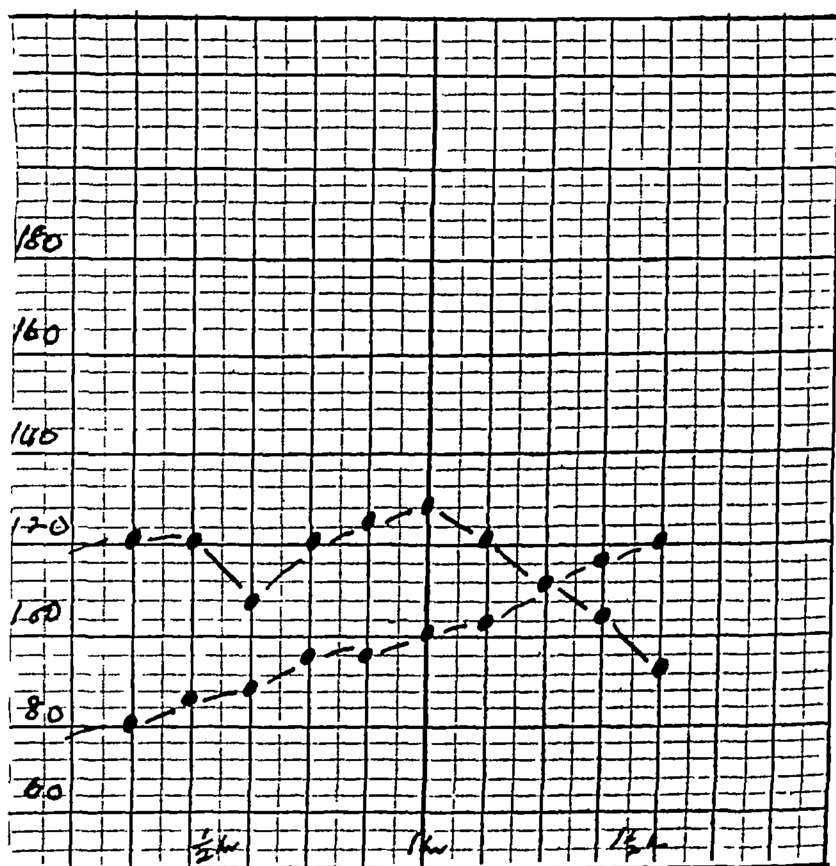


FIG 164 Pulse and blood pressure chart in a case of shock

If shock is divided into slight, moderate and severe, the following figures correspond roughly to these stages —

	Pulse	Blood Pressure	Blood Volume
Slight	100 plus	100 minus	75 per cent
Moderate	140	70	65 ,,
Severe	160	60	50 ,,

They can only be approximately correct Other considerations may make them incorrect For instance, a patient who goes on to the table with a blood pressure of 200 or more may cause anxiety long before it drops to 100

of hospital practice when no blood at all is available? Plasma with all its drawbacks restores the circulating volume and will *faut de mieux* replace a loss of up to two pints Failing plasma polysaccharide solutions can be relied on to remain in the circulation and maintain the blood volume — but they do not carry oxygen and will not sustain tissue cells Moreover these solutions by the fact of remaining in the circulation may add to the difficulties of adequate transfusion later on when blood becomes available It should be noted also that they interfere with grouping so the specimen for the laboratory should always be taken before the infusion is started

Nevertheless such measures have their uses especially in time of war And even without them it may be some consolation to know that shock is part of nature's first aid and may contribute to recovery so long as it does not go too far or is not aggravated by premature surgical interference It may be necessary to tie off a vessel or splint a limb in a badly wounded

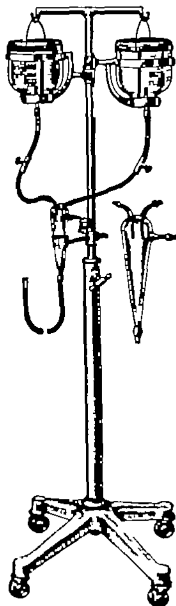


FIG 165 The Officer drip apparatus (*Principles and Practice of Rectal Surgery* Gabriel H K Lewis and Co Ltd London)

when a juncture of this kind arose in an operating theatre that the surgeon and anæsthetist began to wonder what the patient's blood group might be and where it would be possible to find another compatible with it. As a rule a donor had to be sent for from outside the hospital, but even when he was at hand half an hour or more was usually wasted while amateur pathologists made frantic efforts to match his blood. In a modern hospital service this is done beforehand in the laboratory. The grouping of blood is too intricate a business to be carried out in a hurry. Not only must the two bloods be grouped, cross matched and Wassermann tested, but the rhesus factor in each must be allowed for. No one but a trained pathologist is capable of properly attending to such detailed investigations. Even so mishaps are not uncommon. It is difficult to give exact figures in a matter like this, because of a natural reticence on the part of those concerned, and because many deaths are blamed on the primary disease rather than the transfusion. Anuria following prostatectomy, for instance, is not attributed to incompatible blood, when there is a so much more acceptable explanation to hand. Nevertheless it is estimated that this procedure carries a mortality of 0.5 per cent., and a much higher morbidity. In a real emergency a surgeon may be justified in taking a chance and relying on the cross matching of his assistant, or giving a patient who has not been grouped at all a transfusion of group O blood, but in routine work a supply of blood which has been proved in the laboratory to be suitable in every way should always be available in the theatre for every patient who is undergoing a major operation.

It is worth remembering that, under anæsthesia, even gross incompatibility does not give the usual warning signs of shivering and lumbar pain.

What of the emergency which arises outside the compass

intravenously and 1 ml intramuscularly can be given to get a quick response Pitressin ½–1 ml and ephedrine ½ gr are other drugs which can be used to raise the blood pressure All these should be ready in the theatre for instant use Their effect quickly wears off but the dose may be repeated Noradrenaline constricts the peripheral vessels and so raises the blood pressure without increasing the cardiac output but it must be given through the medium of an intravenous drip a 4–8 mgm ampoule to the litre and the dosage kept under constant supervision with the help of a sphygmomanometer Escape of the solution from the vein may cause widespread ischæmic necrosis a complication which has been known to occur in the leg even without leakage.

The Flow of Blood. Two pints of blood will usually be needed in these cases and sometimes four or more. The rate at which it is administered depends on the degree of shock Forty drops a minute = 600 ml in four hours is the ordinary drip rate but it may be advisable to increase this very considerably perhaps to 120 drops a minute when there is bleeding No harm can come from rapid replacement of a recent loss If the hæmorrhage has been really alarming the blood can be poured in Old people s tissues are particularly sensitive to hypotension and with them the need is peculiarly urgent So long as the blood pressure remains under 100 the heart will not be em barrassed by the influx When it goes above 100 the time has come to slow down it is never necessary to push it above 110

The rate of flow depends much more on the calibre of the needle than the height of the bottle doubling the height of the bottle other things being equal doubles the rate of flow but doubling the size of the needle multiplies it sixteen times

As shock deepens the veins constrict and it becomes

man, but to do more than this, before he has been resuscitated, is an offence deserving field punishment The shock in such a case may not be apparent when the patient is first seen For all that, if the injury is sufficiently severe it should be anticipated and treated before it develops The same principle applies here as in the management of burns, and the details have been systematised to some extent [1]

The average blood volume in a man is about 5 litres A single major fracture deprives him of one-fifth of this, two major fractures of two-fifths, and so on With soft tissue injury the open or closed hand may be used to measure the extent of the injury and make a rough estimate of the loss One hand roughly corresponds to ½ litre Replacement proceeds accordingly

To Avoid Delay Even in an operating theatre there may be delay in getting the blood into the patient The apparatus must be set up before the blood begins to flow, and this may take time, so much time that there is a strong argument for starting an intravenous glucose drip at the beginning of any operation that is likely to cause shock or hæmorrhage Glucose solution itself is quickly washed out of the circulation and is of very little service in combating shock, but blood can be substituted for it at a moment's notice, and this is what the patient really wants When the Officer's drip equipment is used the change over from one to the other is made by turning a cock and is almost instantaneous [2]

If foresight has not gone so far and an emergency arises, the danger period between the time when the pulse begins to rise and the time when the transfusion starts can be tided over by giving analeptics [3] Methedrine, 1 ml

[1] M R C Memo No 34 Treatment of wound shock

[2] It is rarely necessary to warm blood and never otherwise than by standing it in water at 37° C Heating causes hæmolysis

[3] Analeptic restorative medicine or agent

2 per cent procaine into the drip is worth trying When none of these measures succeed a Higginson syringe can be attached to the inlet of the bottle and air pumped in to create a positive pressure This manœuvre never fails but it carries a grave risk of air embolism Patient and transfusion set should never be moved while the syringe is attached and a doctor should always remain in control

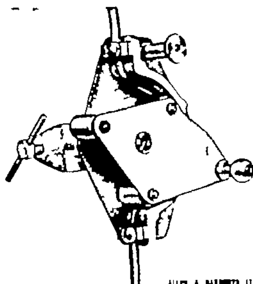


FIG 166A. Martin's transfusion pump The tubing is passed between the rollers. (*By courtesy of Messrs Allen and Hanbury*)

Also the bottle should be changed as soon as it is two-thirds empty because the lower third of the mantle tends to become sludge coated and air may be forced through the upper third

The apparatus illustrated provides for positive pressure without this danger but it is not always available when the need arises It consists of three rollers mounted on a rotating spindle The tubing can be led round the rollers without disconnecting any part of the giving set By

increasingly difficult to find a way into them with a needle When the condition is established veni-puncture may be impossible, and time is then saved by cutting down

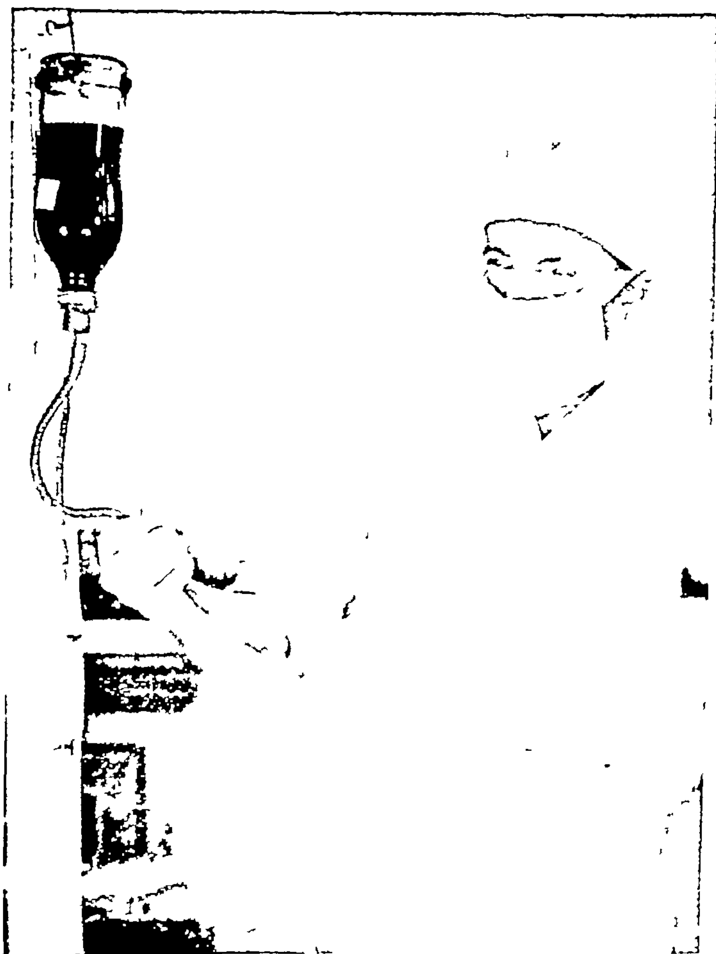


FIG 166 Using a Higginson syringe to create positive pressure in a blood bottle Note that the "clip is below the drip", this lessens the risk of air embolism

straightaway and introducing a cannula into the lumen Even so the blood sometimes does not flow Warming the limb may relax the spasm Raising the blood bottle or milking the supply tube may help Injecting 2 ml of

get near the arms But phlebitis may follows its use especially from infusions of glucose solution and this can spread to the main veins as in the case described Femoral thrombosis being an ever present menace to the convalescent patient there can be no justification for running even the small risk of initiating it in such a way

The presence of the needle itself in the vein predisposes to thrombosis and this may have something to do with



FIG 169 A deliberate scissors cut into a vein is the surest way of getting the cannula into the lumen

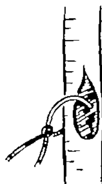


FIG. 170. This blunder with the fixation suture for a cannula lead to air embolism and death.

the friction of its sharp end against the intima The West Middlesex needle gets round the difficulty It consists of a stilette and cannula when the stilette is out the blunt cannula cannot scratch the intima Moreover it can be thrust well up the vein so reducing the chances of dislodgment very considerably Alternatively a length of polythene tubing may be passed through the cannula which is then removed The tubing can be threaded in to any desired extent and the method has been used for

turning the handle blood is forced into the circulation, if need be, at the rate of a pint in a couple of minutes Intra-arterial transfusion, with its attendant difficulties and risks, need never be resorted to if this device is at hand

Venoclysis. The custom of using the antecubital fossa veins for infusion and transfusion is so well established that it seems impossible to alter it in spite of all its disadvantages These veins are not really suitable for the purpose, least of all when it is intended to continue the drip for any length of time after the effects of the anæsthetic have worn off The lie of the needle in an antecubital vein may easily be disturbed during the restlessness of recovery, or by voluntary movement later on Splinting is a safeguard, but such immobilisation is irksome and undesirable The need for it can be avoided by using a vein on the back of the forearm or wrist towards the radial side, so that the arm can rest comfortably on its ulnar side If the tubing is slack and a loop is loosely included in the fixation it will allow all the freedom of movement that is likely to be required

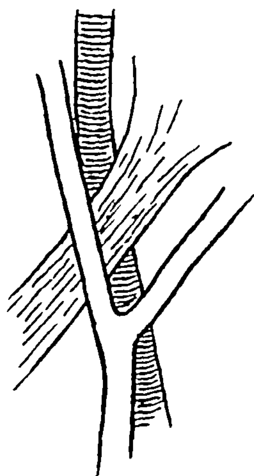


FIG 167 The brachial artery is only separated from the basilis vein by the bicipital fascia, a mistaken injection into the artery may cause spasm leading to gangrene of the extremity

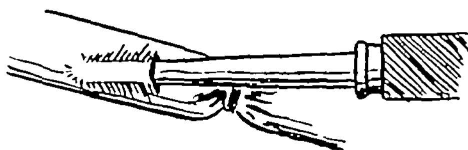


FIG 168 Venoclysis sometimes fails because the point of the cannula is in the wall of the vein instead of in its lumen

The internal saphenous vein at the ankle is often quite accessible in the operating theatre when it is difficult to

get near the arms But phlebitis may follows its use especially from infusions of glucose solution and this can spread to the main veins as in the case described Femoral thrombosis being an ever present menace to the convalescent patient there can be no justification for running even the small risk of initiating it in such a way

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FIG 169 A deliberate scissors cut into a vein is the surest way of getting the cannula into the lumen.

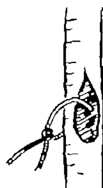


FIG 170 This blunder with the fixation suture for a cannula lead to air embolism and death.

the friction of its sharp end against the intima The West Middlesex needle gets round the difficulty It consists of a stilette and cannula when the stilette is out the blunt cannula cannot scratch the intima Moreover it can be thrust well up the vein so reducing the chances of dislodgment very considerably Alternatively a length of polythene tubing may be passed through the cannula which is then removed The tubing can be threaded in to any desired extent and the method has been used for

delivering solutions of high concentration into the central blood stream

General Measures The immediate cause of death in shock being anoxæmia, oxygen is an essential adjuvant to transfusion But it should not be forgotten that oxygen is useless unless the circulation is sufficiently strong to carry it round the body Of all tissues those of the central nervous system are most vulnerable to this form of starvation For that reason it is advisable to put the patient in a moderate Trendelenburg position and keep him there until the blood supply to the brain is improved, even when this means keeping him in the theatre long after the operation is finished If he is already in a Trendelenburg or other unusual position the greatest circumspection should be observed in altering it to the horizontal

Case Note At the end of a synchronous combined excision of rectum the surgeon performing the perineal part of the operation lowered the legs very slowly and deliberately one at a time, with a pause between the two In spite of the care taken the blood pressure fell from 130/90 to 60/20 within three minutes

Similarly with the change from the dorsal decubitus to the lateral in an abdominal-perineal removal of the rectum, the same precautions should be observed

The move from table to stretcher and from stretcher to bed throws a further strain on the cardio-vascular system This can be lessened by bringing the bed into the theatre, or, if need be, by wheeling the operating table into a recovery room and leaving the patient on it until he is fit to go back to the ward

During the stage of recovery steps should be taken to restore the body temperature, but it is a mistake to turn a cold sweat into a hot sweat A shocked patient is

easily burnt because the heat is not conducted away from the skin to the rest of the body

Choice of Anæsthetic. A spinal anæsthetic causes a drop in blood pressure by paralysing the sympathetic nerves. It should therefore be avoided when there is a danger of shock unless perineal anæsthesia is *all* that is required

Chloroform and ether both possess toxic properties and are equally undesirable Nitrous oxide and oxygen or one of the newer inhalants given in a closed circuit to reduce heat and vapour loss are probably the wisest choices for most occasions but they must be skilfully administered so that anæsthesia is complete and relaxation adequate *Failure in either of these respects throws the* door open to shock producing stimuli

With these lighter and less noxious anæsthetics the surgeon can sometimes help by supplementing the general anæsthetic with a local particularly when his task involves cutting important nerves A couple of cubic centimetres of novocaine injected into the sciatic nerve may cut off more dangerous impulses than a whole bottle of chloroform Similarly with the parietal peritoneum where a quick infiltration may save a lot of anæsthetic. By these measures sub-conscious sensitivity which persists much longer than conscious is abolished in the early stages of anæsthesia The anæsthetist now has curare to help him in obtaining relaxation without deepening anæsthesia This drug paralyses muscle but fortunately does not cause any notable drop in blood pressure

Infusion Pre-operative loss of fluid has been mentioned as a contributory factor in the production of shock and some of the conditions in which it occurs have been listed But it may be present in some degree in almost any case if the nursing staff work on a no patient going to the theatre to have anything to drink after such

and such an hour " rule With such a routine the last patients on the list are bound to suffer If on top of this the operation turns out to be a lengthy one, perhaps accompanied in its later stages by a good deal of sweating, and followed by prolonged unconsciousness with vomiting on recovery, the sum of fluid withheld and fluid lost may be considerable

In the ordinary case, when there are no contra-indications (danger of ileus, operations on the bowel, etc), the difficulty can be met by giving tap water per rectum—tap water is better tolerated by the colon than either glucose or saline solutions But with a really ill patient the intravenous drip is the safest and surest method It should be set up in the theatre, irrespective of the presence or absence of shock, and kept going for forty-eight to seventy-two hours after operation At the same time a Ryle's tube is left in the stomach for aspiration of any residue there may be Most surgeons make a practice of doing this with all their big abdominal cases until the bowel has given indisputable auditory and olfactory evidence of having resumed its activity The sooner fluid is given by mouth the better, of course, this being by far the safest route and carrying none of the risks of prolonged intravenous therapy, but it is a mistake to ignore nausea and vomiting, or force drinks on a patient with a splashing, dilated stomach, merely in order to avoid these risks

Fluid Balance Renal function is always depressed after operation, with the result that fluid is retained in the body for twenty-four hours or more, and salt for several days This phenomenon suggests that particular caution should be exercised with intravenous therapy in the immediate post-operative period And it argues very strongly against precipitate operation in patients who are suffering from electrolytic imbalance In such cases

surgical interference is likely to aggravate the imbalance and is certain to invalidate the tests used for measuring it so multiplying difficulties and dangers of correction a hundredfold.

Intravenously one and a half litres of 5 per cent glucose and half a litre of normal saline will be sufficient for the first twenty four hours unless there is any abnormal loss *e g* by sweating [1]

By the day after operation the kidneys should have recovered So far the fluid chart has not been much use but now a diuresis may be expected to even up the figures and subsequent dosage must be based on the relationship between intake and output.

Supposing the patient were a perfectly healthy person going about his day s work in temperate climate his daily intake and output might be represented thus —

Intake	*Output*	
3 000 ml (half in food)	Renal	1 500 ml
	Extra renal (in expired air invisible perspiration and fæces)	1 500 ml.

Maintenance in the post-operative case can be based on this but it is assumed that the patient is not taking anything by mouth and accordingly the whole of the three litres must be given intravenously Half a litre of this will be normal saline the rest 5 per cent glucose But there are other factors to be taken into account The patient may be sweating and visible sweat as opposed to invisible contains sodium chloride perhaps in considerable quantity though never to the point of isotonicity The three litres must be increased to allow

[1] Le Quesne P L. *Fluid Balance in Surgical Practice* Lloyd Luke

for this, though by how much may be a matter of opinion It will need to be increased also if there is any vomiting or gastric aspirate Nor will it cover the loss into the bowel in a case of ileus, which, so far as the circulation is concerned, is just as real as any other loss These losses must be replaced by normal saline When they are measurable, as with vomit or aspiration, there is no difficulty about the amount to be given when they are not, as in ileus, considerable judgement is required

Fortunately, nature allows a wide margin of error, but to the uncertainties already mentioned another must be added The kidney works by fits and starts, and enjoys long spells of idleness in between This means that fluid balance must not be reckoned from hour to hour but from day to day The opportunities for miscalculation are obvious, and it is not surprising that things sometimes go wrong in spite of the greatest care Nevertheless, there can be no question that the prevention of dehydration is far easier than its cure, and no effort should be spared to anticipate its development in a patient under observation In a patient seen for the first time the best that can be hoped for is early recognition and prompt treatment

Dehydration Even the accurate diagnosis of this condition is fraught with difficulty, because fluid balance is intimately connected with electrolyte balance Each acts and reacts on the other in an intricate and often unpredictable manner and no tests can really be relied on to take the measure of their interplay

Two types of disturbance require consideration—dehydration due to lack of water, known as primary, and dehydration due to lack of salt, known as secondary

Lack of water leads to an immediate rise in the specific gravity and at the same time the osmotic pressure of the extra-cellular fluids of the body, an alteration that is quickly corrected by withdrawal of sufficient fluid from

the cells to restore normality A cellular dehydration results.

Lack of salt both in its causation and results is less easy to understand Its cause is not necessarily a deficient intake although this is a factor whenever the patient is not on a normal diet as after operation More often it is due to an excessive loss in sweat urine or intestinal secretions

Whatever the cause of the salt deficiency the first effect is a lowering of the specific gravity and at the same time the osmotic pressure in all the body fluids This has the undesirable effect of promoting diuresis by reducing re-absorption of the glomerular filtrate from the tubules and for the same reason it interferes with absorption from the alimentary canal Losses therefore continue while supplies are reduced if not abolished and the stage is set for a steady deterioration until there is no longer any fluid to secrete

This type of dehydration differs from the one previously described in affecting the extra-cellular fluids instead of the intra-cellular and in being more far reaching and ineluctable in its consequences

Measuring the Deficiency It is alleged that no one is more expert at saying Yes and No in the same sentence than a medical author and certainly the criticism is applicable to a great many articles on electrolyte and fluid balance The size of the literature on this subject alone is enough to suggest that finality is still a long way off

The most obvious method of estimating the nature and the extent of the deficiency is by examining and measuring the urine Unfortunately the urine reflects the blood chemistry accurately only when the kidneys are acting normally and results may be quite misleading when they are handicapped as in the post operative period The Fantus test for chlorides is quite useless at this stage

The specific gravity may be helpful if the specimen is free of blood and pus The amount excreted is important, but the measurement must be made over several days in order to allow for the vagaries of renal activity

Examination of the blood itself gives results which are sometimes difficult to interpret Figures do not alter until quite late, because of the elaborate adjustment mechanisms which are designed to maintain the isotonicity of the plasma at all costs Even when they do alter, they may be deceptive A normal plasma chloride may mean that the chlorides are normal, or that the plasma is abnormal, *i e*, reduced in volume A high blood urea may mean that the kidneys are not working properly equally it may mean that the patient is dehydrated And hæmoconcentration may be masked by anæmia

Nevertheless, the laboratory reports provide valuable confirmatory evidence, and are specially useful when the figures obtained on one day can be compared with those on the next

Some Normals

Urea	25 mgm per 100 ml
Na	315–340 mgm per 100 ml
Cl (as NaCl)	560–630 mgm per 100 ml
K	15–20 mgm per 100 ml
CO_2 combining power	55–75 vols per 100 ml

But electrons combine with each other by equivalent weights, not by milligrams It has become customary, therefore, to take notice of these equivalent weights rather than the actual weights, and to deal in litres instead of 100 ml The equivalent weight of an electrolyte per litre, or for short its M Eq/L, is discovered by multiplying the mgm per cent figure by 10 to get the quantity in a litre, then dividing by its atomic weight, and finally multiplying by its valency Or, to simplify, dividing by

2 3 for sodium
5 8 for chloride
3 9 for potassium
2·2 for CO_2

The M Eq/L corresponding to the normals given above are —

Na	137–147 8	M Eq/L
Cl (as NaCl)	100	M Eq/L
K	3–5	M Eq/L
CO_2 combining power	24–34	M Eq/L

An example will illustrate the difference between the two systems of measurement A litre of normal saline contains 3 54 grm. of sodium and 5 45 grm of chlorine If M Eq are substituted the figures are 154 M Eq and 154 M Eq accordingly saline is not acid but neutral in reaction.

Symptoms and Signs Happily the clinical problem is less bewildering than the bio-chemical Men are more important than books

The patient suffering from pure water depletion is thirsty his mouth and tongue are dry he excretes only a small amount of urine which has a high specific gravity his blood urea is raised and he becomes drowsier as time goes on A man who is afraid to drink because of acute retention may present this picture when he reaches hospital Once the retention is relieved and drinking resumed symptoms clear up very rapidly

A patient suffering from salt depletion complains of nausea instead of thirst and vomits anything he is given to drink His tongue remains moist although it is shrivelled up and he continues to excrete urine of low specific gravity But the look and feel of his subcutaneous tissues advertise the state of his interstitial tissues generally His skin is lax and inelastic and does not

recoil when it is pinched up (but this is natural in old age) his muscles have a putty-like consistency, the tension in his eyeball is diminished, and the eyeball itself has a tendency to recede into its socket. At first the blood pressure is maintained, although there may be postural giddiness. Later peripheral pallor and cyanosis develop, owing to the diminished volume and increased viscosity of the blood, which shows hæmoconcentration and a high urea content. The general appearance may suggest heart failure, and some of these cases are missed in consequence. Even when this pitfall is avoided another lies ahead. Drowsiness deepening into coma, at a time when the kidneys are giving up the unequal battle and the urinary secretion begins to fall off, is very likely to lead to a diagnosis of uræmia. Either mistake may well be responsible for a fatality that might easily have been prevented if the clinician had taken warning from the apathy, vomiting, and loss of skin elasticity in the earlier stages.

Treatment. From what has been hinted it may well be surmised that the treatment of dehydration must be empirical in many cases. If the deficiency in intake and abnormal losses are charted and known this need not be so. A simple addition taking into account the daily basal requirements will give the amount needed to restore the *status quo*. But very often the figures are not available and then treatment must be by rule of thumb.

as normal saline the rest as water—that is to say 5 per cent glucose for water itself is never given intravenously and glucose has the advantage of sparing protein metabolism Daily renal and extra renal losses must of course be added to the total The replacement is spread over two days or more which allows ample opportunity for revising the dose either up or down Watch should be kept on the external jugular vein in the neck for the engorgement which is the earliest sign of over dosage and the chest should be auscultated regularly for the moist sounds that presage an œdema of the lungs

Fluid supplied in this way is used first of all in the insensible loss next for tissue requirements and finally to make up the volume of urine As the treatment proceeds therefore an improvement will be noticed in the patient s general condition and at a later stage his urinary output will increase When this amounts to 1 000 ml a day with a specific gravity of less than 1 015 a normal 1 per cent chloride content and the blood urea also is within normal limits he may be considered cured at least of his dehydration.[1]

Oliguria and Anuria It is of course essential to safety that the kidneys should be able to excrete any fluid in excess of requirements A diminishing output *in spite of treatment* is therefore a danger signal. If the twenty four hour figure falls below 500 ml. a state of emergency is at hand. Treatment of dehydration must then be suspended until renal survival is assured.

The principle of treatment in these cases is to put the kidneys completely at rest until their recovery is assured When oral feeding is not contra indicated 400 ml. of 40 per cent glucose can be introduced into the stomach through a

[1] The tendency to thrombosis in the vein round the needle during prolonged therapy is lessened by adding 500 units of heparin to each half litre of fluid this does not affect the clotting time

Ryle's tube each twenty-four hours. The glucose supplies sufficient calories to discourage any breakdown of body proteins, so that protein metabolism is eliminated. There are no electrolytes in the solution and only enough fluid to replace the extra-renal loss. All vomit is returned surreptitiously through the Ryle's tube (fat, formerly administered with the glucose, has been omitted as too nauseating). If there has been any urinary secretion during the previous twenty-four hours an equal amount of water is added to the daily 400 ml. Penicillin is given in the small doses which are sufficient to maintain a blood level when the kidneys are not functioning; other antibiotics are better avoided because of the danger of accumulation. Vitamins are prescribed in the usual doses. Should the patient be unable to retain anything by mouth the problem of supplying the caloric requirements can be met by giving glucose 40 per cent. or 10 per cent. invert sugar with 5 per cent. ethyl alcohol, and sometimes even stronger solutions, intravenously, preferably through a polythene tube passed up into the vena cava.

When the urinary output returns to a litre in the twenty-four hours on this regime, tube feeding can be discontinued in favour of the high calorie, low protein diet which is appropriate to any uraemic condition. A pint of milk to which aluminium hydroxide has been added in order to precipitate phosphate and prevent its absorption contains as much protein as is required per diem.

loss is quickly made up when a normal diet is resumed so that replacement is seldom a matter of urgency Never theless the need may arise when intravenous therapy continues for some time.

The symptoms of potassium deficiency are muscular weakness progressing to paresis and what is more obvious in an ill patient an ileus paralyticus Characteristic changes can be recognised in the electro cardiogram.

Whenever possible correction should be by the mouth potassium citrate gr 40 six hourly for 24–48 hours It is never safe to give potassium intravenously until salt and fluid balance is adjusted and the kidneys are acting well Even so dosage must be cautious and solutions weak. Potassium chloride 3 grm to the litre is a suitable dilution and 2 litres of this should never be exceeded in the twenty four hours

In children. Fluid balance is much more delicate and easily upset in children than in adults A day s deprivation may produce serious consequences and even less than a day if there are losses to be reckoned with as well as deprivation

Correction must be correspondingly cautious with particular care against over dosage. The usual mainten ance rate is 1 grm of sodium chloride or 126 ml of normal saline per diem for infants and 3 grm or 350 ml of normal saline for children water 165–100 ml per kgm of body weight for infants and 100–45 ml per kgm for children (notice that the allowance is relatively more generous in the smaller subject because the loss is rela tively greater) Additional losses must of course be replaced quantitively and qualitively as in the adult Fortunately in the child a daily weight is easy to obtain and this must help greatly in controlling dosage

Fluid Charts No one who has to do with fluid charts fails to find fault with them at some time or other The

fact that relays of people are responsible for filling them in, and that two different systems of measurement are used makes confusion almost inevitable In spite of these handicaps, much ambiguity would be eliminated if the ward sister made an invariable practice of marking the twelve-hourly totals herself, and doing it while she still had the opportunity of cross-questioning the members of her nursing staff responsible for the original entries

CHAPTER XXIII

ANÆSTHETIC EMERGENCIES

The Cardiac Risk. Under modern conditions the operative risk in patients with heart disease is much less than it used to be It is true that recent myocardial infarction or increasing anginal pain are contra indications to all except unavoidable surgery but in other cases reasonable precautions will prevent mishap A week or two in bed before operation with digitalis when required is often all that is necessary to make the patient safe for surgery

A smooth induction is essential in these cases to avoid any stress or strain on the circulation Thereafter oxygenation should be adequate throughout and the blood pressure must never be allowed to fall below 100 An ischæmic myocardium will function quite well so long as it receives an adequate supply of sufficiently oxygenated blood Otherwise arrythmias failure or ventricular fibrillation may develop at any time

During and after operation intravenous fluids should be given with due care against overloading the system Engorgement of the neck veins is always a danger sign These patients are particularly liable to thrombotic and embolic complications and such dangers must also be guarded against

The Grey Patient No greater emergency can arise on the table than cessation of the heart beat whether it be due to anæsthesia the action of a drug vagal reflex or air embolism When a pulse can no longer be felt in the carotids (or any other great vessel accessible to the surgeon) the time has come for rapid action Cases have been reported in which the heart resumed its beat after

fifteen minutes, but the tissues of the central nervous system will not stand oxygen deprivation for anything like this length of time. Every effort must be made, therefore, to remedy the situation without delay. It is poor consolation to send a live patient back to the ward with a dead brain.

Success depends on (*a*) restoring the circulation by cardiac massage as quickly as possible, and maintaining this until the heart resumes its function; (*b*) supplying enough oxygen for all requirements.

The steps to be taken are:—

(1) Put the patient in a Trendelenburg position to help the cerebral circulation. Start positive pressure ventilation of the lungs.

(2) Pass a long needle backwards and slightly inwards through the third right intercostal space to reach the auricle. The mechanical stimulation may start it beating.

(3) The injection of drugs is time consuming and not without danger. It is now realised, thanks to the direct observation of the chest surgeon, that the heart has not always ceased to beat in these cases. Sometimes the ventricles are still fibrillating ineffectively, in which case adrenalin may do harm. If there is no response to the needle prick, and the abdomen is open, the heart should be massaged against the sternum by a hand below the diaphragm, at the rate of about forty times a minute. Or the diaphragm and basal pericardium may be divided and the hand inserted through the incision to grasp the heart and squeeze it. If the abdomen is not open the quickest and most satisfactory approach to the heart is by a bold incision over it, from the edge of the sternum to the mid-axillary line, avoiding the internal mammary vessels but retracting the ribs wide apart. This may appear a considerable undertaking to one who is not accustomed to operating in the thorax, but is really quite

a straightforward procedure and more than justified by the circumstances of the case When necessary the pericardium is split and both hands used to grasp the heart In this way a very effective circulation can be set up and carried on indefinitely so that even the extremities resume their normal colour But the heart muscle is friable and care must be taken not to damage it by the massage which should be the work of the palms and not the finger tips

Meanwhile drugs can be tried Adrenalin 5—10 ml of 1/10 000 has hitherto been a favourite but it should not be used before the myocardium is oxygenated and great care should be taken to see that it is never injected into the muscle itself where it is likely to cause an ischæmic necrosis Calcium chloride 5—10 ml of 1 per cent has its advocates Procaine 5 ml of 2 per cent will sometimes cure a fibrillation if massage does not succeed.

When everything else fails a fibrillating heart can be stopped completely by passing an electric current through it massage may then restore a normal rhythm A special apparatus is required for this purpose

The Blue Patient In the ordinary way laryngeal obstruction is a problem for the anæsthetist to deal with but if he fails in his efforts the surgeon may be called upon to carry out an emergency tracheotomy

Such an event is quite a rarity in modern practice except possibly in connection with œdema of the vocal cords This condition may be present as an extension of inflammation anywhere in the neighbourhood and what is more it may be present without causing symptoms Quinsy retro pharyngeal abscess Ludwig s angina have ended fatally because this complication was not suspected or the anæsthetic was mishandled The exact cause of death is not always clear

Case Note A soldier attended the M I room with adenitis of neck He was given a fomentation and excused duty Next day, when the battalion, with its medical officer, were away on manœuvres, he reported to the M I room again, saying he found it difficult to breathe The orderly gave him a glass of water, and while drinking it he dropped dead Post mortem there was laryngeal œdema, but it did not seem that death was due to asphyxia

The casualty department is not the proper place to operate on such cases, and anæsthesia must be conducted with the greatest circumspection Any intra-pharyngeal abscess should be opened under local anæsthetic, so avoiding the double risk of laryngeal spasm and drowning by aspiration of pus Local anæsthetic can be used externally also Intravenous anæsthetics of any kind are tabu All these precautions, notwithstanding a set of tracheotomy instruments, should be ready for immediate use, and there should be no hesitation over the steps of the procedure, which is briefly described here

While the anæsthetist holds the head quite straight and fully extended, the surgeon grips the cricoid between the middle finger and thumb of his left hand and makes his incision dead in the mid-line of the neck Bleeding is likely to be alarming because of the congestion, but no attempt should be made to stop it at this stage The cricoid is now fixed and elevated with a special hook made for the purpose, this acts as a landmark during the remainder of the operation With an assistant retracting the edges of the wound on either side the tracheal rings come into view The second and third of these are divided from below upwards, ignoring the isthmus of the thyroid, but taking the greatest care not to damage the thin posterior wall of the trachea or interfere with the cricoid, on which depends the patency of the rings, all of which are defective behind The blades of a dilator are at once inserted into the trachea, followed by the tracheo-

tomy tube on its introducer When the introducer is removed and the patient takes his first gasp of air then and only then hæmostasis can be attended to It is particularly important to clear the respiratory passages of any blood that may have found its way into them

A laryngologist should supervise the after care and decide when to remove the tube It cannot be discarded until a track has formed

Aspiration of Stomach Content. A recent investigation suggests that this accident is much more frequent than was formerly thought and is responsible for nearly a quarter of all anæsthetic deaths The figures include deaths from laryngeal spasm caused by irritant particles lodging on the cords and from post-operative complica tions such as pneumonia and lung abscess as well as the more familiar death by drowning from massive inhalation The real cause of the trouble passes often unsuspected and it appears that the use of muscle relaxant drugs has contributed to the danger

To operate on a patient with a full stomach is asking for trouble and it should be assumed that the stomach is full unless it is known not to be Almost all emergency operations are subject to this danger with the possible exception of appendicectomy when the initial vomit usually forestalls it Accident cases are particularly prone because shock and sedation both delay the emptying time of the viscus beyond the normal four to five hours Obstruction at any level is very commonly accompanied by an overfull stomach The patient who bursts his abdominal wound is another risk Diabetics are some times given glucose solution by mouth before going to the theatre This is not safe because the solution is hyper tonic and attracts a large quantity of fluid from the mucosa by osmosis The glucose should be given intravenously

In these and other cases when the stomach is likely to

contain semi-solid material, a Ryle's tube will not empty it A small bore stomach tube should be passed before the induction of anæsthesia (it is the only tube that can be safely passed after induction), and left until the larynx is protected by a cuffed intra-tracheal tube, or alternatively, the cough reflex has returned and the patient is recovering consciousness Even with this type of stomach tube considerable manipulation may be needed to drain off the content from different levels

Aspiration of vomit is an accident that may occur just as easily during recovery from anæsthesia if the patient is not properly looked after The semi-prone position with a pillow under the chest and the lower arm drawn back is the only safe one Any fluid that regurgitates will then drain away by gravity, and the chances of its trickling into the larynx are minimal

Air Embolism Every surgeon knows that if he injures a vein when he is operating at the root of the neck air may be sucked into the heart and the patient die of it The same thing may happen during dissections of the axilla, as for a radical breast operation A post-mortem report made after such an accident mentions " An impressively large volume of gas This must have almost completely filled the right side of the heart " It seems that the rent in the vein was held open by traction on the mass of tissue being separated from it while the air found its way in without any of the gurglings or hissings which are expected on these occasions

Prompt pressure of a pack is probably the best way of preventing further trouble Then when opportunity offers the vein can be tied off *proximally first* If the first ligature is distal the blood stream is interrupted by it and the empty proximal lumen invites fresh embolism Meanwhile measures must be taken to resuscitate the patient It is not likely that efforts to empty the heart,

either by a catheter passed down the torn vein or by a needle plunged into the right auricle will succeed So it is better to rely on artificial respiration and cardiac stimulants in the hope of tiding over the worst

There are many other ways in which air embolism can arise ranging from mishandled urethroscopies to clumsiness in evacuating the pregnant uterus These cases are not always fatal because a healthy circulation can deal with a considerable amount of air particularly if it enters slowly Not so when the circulation is failing as it is during transfusion for shock or hæmorrhage It is fairly certain that in these circumstances as little as 10 or 15 ml may be enough to kill the patient by blocking the coronary arteries or the arteries going to the vital centres in the brain Post mortems have shown more than once that patients who have collapsed while being transfused owed their deaths to such a mishap although the air could only have found its way into vein bubble by bubble over an hour or more Therefore every care should be taken when inserting a cannula into a vein or setting up a transfusion apparatus to see that there is no gap in the defences

The set should be entirely filled with blood before the vein is punctured with the needle and nursing staff should be instructed always to change the bottle before it is empty and clamp the tubing just above the drip while this is being done Even a puncture left in the tubing after injecting a drug may have disastrous consequences if it is situated above the lower fluid level

Operating Theatre Explosions Ignition and explosion of anæsthetic gases only occur in an exceptionally dry atmosphere and are therefore not common in this country Nevertheless reports of such accidents are becoming more frequent This may be explained by the drying effect of certain types of artificial ventilation or the increased use of electrical apparatus

Ether, cyclopropane, and ethyl chloride are all inflammable—ether notably so Nitrous oxide is not inflammable itself, but encourages and supports combustion of other gases Clearly no inflammable agent should be administered where there is a likelihood of its being ignited, as while cautery or diathermy are in use Ether is so treacherous in this respect that the bottle should be taken out of the room until the danger is past

But there are other and less obvious ways in which ignition can occur—by the sparking of defective electrical apparatus, or by the discharge of static electricity

The disparity between endoscopic lamps and the work which they are called upon to perform is an ever present cause of complaint, and sometimes of accident Electrical switches of all kinds are apt to spark, and it is wise to fit them outside the theatre rather than inside Foot switches, unfortunately, cannot be excluded in this way The motor of a suction apparatus is another possible source of danger Situated on the floor, as it usually is, any heat which it produces must be in dangerous proximity to a gas that has sunk to the same level

When the air is sufficiently dry, equipment and, indeed, persons, working in an operating theatre may become electrically charged This static electricity may discharge with a flash if circumstances are propitious The remedy is to earth all trolleys to a conducting floor, and to see that rubber boots are conducting also

It is perhaps needless to add that the risk to the patient, however it arises, is magnified a hundredfold when the operation involves his air passages A flame sweeping down the trachea to the alveoli is almost certain to cause death, either immediately or at a later date from bronchopneumonia Explosions elsewhere are less lethal, but the damage may be more widely distributed, and the victim is sometimes one of the bystanders

CHAPTER XXIV

LOCAL ANÆSTHESIA

The Drugs Cocaine *This is much too toxic for injection into the tissues* but works well as a surface anæsthetic.

Procaine and novocaine have the same formula They exert little surface action but act well on injection

Amethocaine has a formula allied to that of procaine

Nupercaine (formerly percaine but renamed to prevent confusion with procaine) is a non irritant quinoline derivative

Amethocaine and nupercaine are both much more toxic than novocaine but also much more potent so that they can be used in quite weak solutions 1/2 000 or 1/1 000 instead of 1/100

Xylocaine is more potent than novocaine but may be used in the same strength or in greater quantity of a weaker strength

All these preparations follow the general chemical rule of keeping better in the dry state than the wet What is more in the dry state they offer little hospitality to micro-organisms If sterile normal saline is used to dissolve them the solution obtained is approximately isotonic and has no irritant effect on the tissues It can be boiled as a final precaution against infection At no stage of the proceedings should the slightest trace of any other chemical substance (alkali iodine mercurials etc) be allowed to find its way into the containers syringes etc used for the anæsthetic or adrenaline

Adrenaline or epinephrin 1 1 000 is added to whatever solution is employed in the proportion of 1 minim to 10 ml

total dose not to exceed 15 minims By producing vaso-constriction it—

(*a*) Reduces hæmorrhage
(*b*) Delays absorption, and so
(*c*) Lessens toxicity and prolongs the action

Any excess of adrenaline will constrict not only the capillaries but the arterioles as well, and these will start bleeding when the action of the drug wears off Accordingly it is important to have the solution accurately dispensed Even when its strength is exactly right, the smallest bleeding points should be dealt with before the wound is closed Hæmotoma formation is one of the complications of operating under local anæsthesia [1]

Slow absorption is very desirable Novocaine by itself ceases to anæsthetise at the end of fifteen minutes, with adrenaline the effect may not wear off for an hour or longer

Adrenaline does not tolerate boiling It should be taken straight from the sterilised ampoule and added to the anæsthetic solution after this has had time to cool

Premedication This is an essential preliminary to any considerable operation carried out under local anæsthesia It should be given at least an hour and a half beforehand The choice of drugs and dosage will depend on the age and constitution of the patient, but combinations of omnopon and scopolamine suit most cases If there has been an oversight and the premedication has been forgotten, morphia gr $\frac{1}{4}$ dissolved in 10 ml of saline can be given intravenously when the patient is on the table

Surface Anæsthesia Aural and ophthalmic surgeons use cocaine freely in dilutions of from 5 to 10 per cent for anæsthetising the nasopharyngeal mucous membranes or

[1] Adrenaline infiltration may be used with general anæsthesia to reduce hæmorrhage when tourniquet control is not safe or must be discontinued

the conjunctiva The general surgeon has not much call for it but it is quite safe and very effective as a urethral anæsthetic The late Edward Canny Ryall founder of All Saints Hospital advocating its use in the preface to

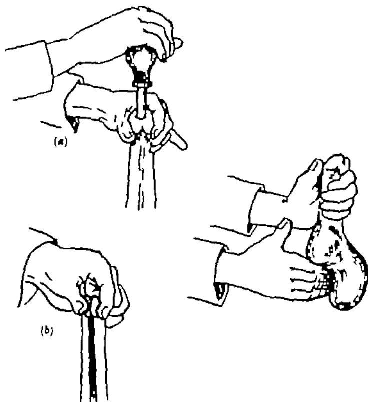


Fig. 171 Urethral anæsthesia (a) Injecting the first two drachms of anæsthetic (b) Nipping the urethra between finger and thumb (c) Milking the solution back into the posterior urethra The anterior urethra is again filled and a penile clamp applied. (After Canny Ryall)

his atlas of cystoscopy wrote The humblest patient has the same claim as the millionaire to the most anxious consideration in this respect an equal right to be spared suffering Canny Ryall employed cocaine constantly and its efficiency has been proved by generations of his successors His formula was —

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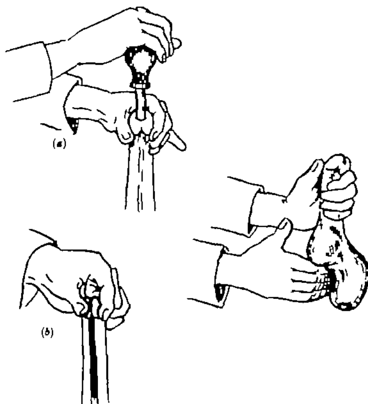


FIG 17 Urethral anæsthesia (a) Injecting the first two drachms of anæsthetic (b) Nipping the urethra between finger and thumb ( ) Milking the solution back into the posterior urethra The anterior urethra is again filled and a penile clamp applied (After Canny Ryall)

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hand and giving him a tablet of decicaine to suck This should become routine ward practice

Infiltration Anæsthesia This is the simplest and most certain method of obtaining deep anæsthesia The technique is straightforward A pig skin wheal is first raised in the skin with a hypodermic needle. The wheal becomes anæsthetic at once and a larger needle of the lumbar puncture type can be pushed through it quite painlessly The solution is then distributed under the line of the incision and afterwards amongst all the deeper layers of the wound. This causes only a minimum of discomfort if the injection is given slowly because these tissues are relatively insensitive

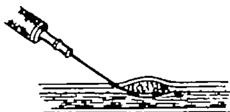


Fig 172 Continuous infiltration of local anæsthetic opens up tissue planes, and clears the way ahead of the needle. If the needle is long and flexible it can be coaxed along with the finger and thumb of the left hand and will be much less likely to pierce a vein than a stiff needle

An underlying aponeurosis like the rectus sheath offers a perceptibly increased resistance to the passage of the needle and gives a sure indication of the depth reached Once through it the solution spreads very readily along the cellular planes in front of the muscle If there is a serous membrane like the pleura or peritoneum lying still deeper it may be possible to identify it in the same way as the aponeurosis Otherwise supplementary injections will be required when

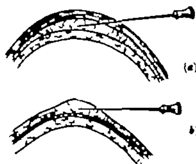


Fig 173. An injection of local anæsthetic into the scalp must be made not under the aponeurosis (a) but into the skin (b)

Cocaine hydrochloride	6 gr
Soda bicarbonate	6 ,,
Chloretone	4 ,,
Aq Destillata	2 oz

The chloretone is a preservative, but even with it the mixture quickly deteriorates It can be omitted altogether if the two other constituents are kept in powder form and only dissolved when required for immediate use For anæsthesia 2 drachms of the solution are injected into the anterior urethra, milked back into the posterior, and another two injected into the anterior A penile clamp is then applied behind the glans and the patient left for fifteen to twenty minutes This will render the mucous membrane of the urethra completely insensitive Unfortunately it will not abolish the discomfort caused by distortion of the canal from the introduction of a straight instrument like a cystoscope

So used, cocaine never causes toxic symptoms, but if there has been previous instrumentation and the urethra is bleeding it is not safe to inject this or any other anæsthetic A broken surface of any kind increases the risks of absorption a hundredfold

Xylocaine jelly forms a convenient alternative to cocaine for urethral anæsthesia, being always ready for use, though it is doubtful whether it is quite so effective

Percaine is another drug which gives surface anæsthesia, and can be used on mucous membranes A 1 per cent ointment, for instance, may relieve painful conditions of the anus

The introduction of a Ryle's tube in a conscious patient is often very distressing, and if done post-operatively the resultant straining may be more than the wound sutures will stand The discomfort and danger can be entirely eliminated by spraying the patient's naso-pharynx before-

the surgeon stands by testing the skin every few minutes and grudging every second of delay until he can start operating he will not only work his patient into an apprehensive and nervous state but will probably finish by losing patience and beginning too soon A watched kettle never boils It is much better practice for the injection to be given by an assistant beforehand if the surgeon gives it himself he should go away and occupy himself with something else for a while then when the other task is complete the anæsthesia is certain to be satisfactory The trouble is worth taking Few things bring more discredit or are remembered longer by patient or onlookers than the infliction of unnecessary pain

Infiltration or for that matter any other form of local anæsthesia is of course quite unsuited to cases in which infection is already present

Regional Block Anæsthesia Regional block anæsthesia gives a virgin field the area to be operated on being walled

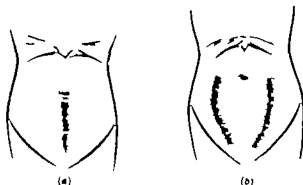


Fig 174 (a) Infiltration anæsthesia for midline abdominal incision (b) Regional block anæsthesia for the same

off with a full depth barrier of anæsthetic solution (Fig 175) leaving the line of the intended incision entirely untouched

It is said that healing is better in consequence but the immediate results are uncertain For an operation like

the wound is open, because the parietal layer of such a membrane is well supplied with nerves

Some surgeons, instead of injecting as the needle advances, prefer to insert it to its full length first of all and then inject as it is withdrawn There seems little to choose between the two methods

An interval, varying in some degree with the strength of the solution used and the tension under which it is injected, must be allowed to elapse before the operation is begun The following is a table of times and doses —

	Time for anæsthesia	Length of anæsthesia	Maximum dose
Novocaine and procaine	Twenty minutes	An hour or more	300 ml of ½% 100 ml of 1%
Amethocaine	Five minutes	Two to three hours	300 ml of 1/1000
Nupercaine	Ten minutes	Two to three hours	300 ml of 1/1500
Xylocaine	Five minutes	Two to three hours	50–100 mls of ½%

Times are approximate and it is assumed that adrenalin is used

Maximal doses are hardly ever needed A quarter as much is usually sufficient In very young or very old people, and in patients who are gravely ill, the maxima given here would not be safe

Whatever solution is employed must be injected with full aseptic ritual The reaction that sometimes follows operation under local anæsthetic, whether indurative or frankly inflammatory, is more often due to careless technique than chemical irritation

One of the commonest reasons why local anæsthetics give poor results is that they are not given sufficient time to take effect Amethocaine and nupercaine act quicker than novacaine, but even they must not be expected to anæsthetise on the spot If, when the solution is injected

solution is needed than for infiltration since it must percolate the trunks of the nerves and not merely their terminal branches

Not infrequently a nerve block can be combined with infiltration to give a very thorough anæsthesia

Splanchnic Anæsthesia. For abdominal operations the innervation of the viscera must be taken into account These are supplied from the sympathetic system by fibres which come off the dorsal and lumbar segments of the cord and have local and remote relays It is possible to



Fig 76 Testing for a bent needle tip

reach most of them by injections made from the back but the feat is a difficult one and failure is not uncommon

The injections are easier to make after the abdomen is opened Solution can then be pooled retro-peritoneally between aorta and vena cava at the level of the first lumbar vertebra to reach the splanchnic nerves and cœliac ganglia The sympathetic can be intercepted elsewhere by injections around the origin of the main arteries—the superior mesenteric the inferior mesenteric the splenic etc

Viscera themselves have no more than a low grade

circumcision the anæsthesia given is good, because all the cutaneous nerves running up the shaft of the penis can be intercepted easily The digital nerves are equally accessible, but gangrene has been known to follow the use of local anæsthetic in the fingers and toes, so it is better avoided, especially in old people

Nerve Block Anæsthesia The third choice is a block of the main nerves supplying the part at a spot where they

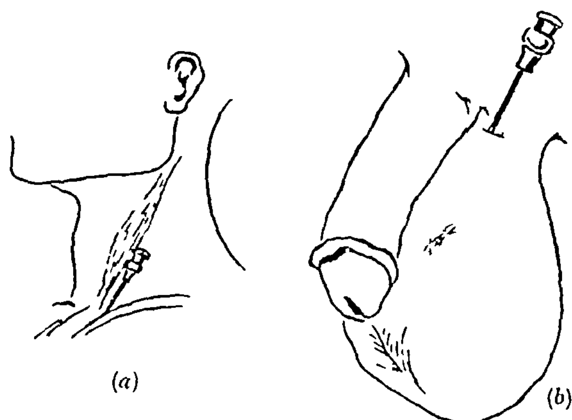


FIG 175 (*a*) Brachial plexus block anæsthesia (*b*) Spermatic cord block anæsthesia

are most easily accessible A sound knowledge of anatomy is required in order to do this with any certainty, and the physique of the patient must permit accurate localisation, although the addition of hyalase, which encourages spread of the solution, may compensate for a certain amount of inaccuracy and may be a help when the recognition of landmarks is difficult

If the anæsthetic solution can be injected directly into the sheath of a bundle of nerves, as sometimes in the brachial plexus, its intimate contact with the axons gives quick and sure results But if it is only possible to inject into the neighbourhood of the nerves the action is less certain and a good deal slower Either way a stronger

standing how a mustard plaster relieves the pain of a pleurisy

Drawbacks and Dangers Every now and again a patient shows an idiosyncrasy to cocaine or one of its derivatives and reacts badly even to small doses A misadventure of this kind is unusual but distressing when it occurs [1]

Actual poisoning is rarely seen now that cocaine is no longer given by injection but when it does occur the symptoms are alarming in the extreme The patient becomes violently excited has difficulty in breathing and may develop twitchings or convulsions Treatment is carried out in the Trendelenburg position by administration of oxygen artificial respiration when necessary and the giving of a barbiturate intravenously In a favourable case recovery is rapid and complete

Precautions There is a greater danger of poisoning from accidental intravenous injection containing adrenaline than from over-dosage Every precaution should be taken against this happening When the whole injection is being made in one spot as for a nerve block the needle should be inserted by itself first of all and the syringe only attached to it if no blood escapes Or if the two are used together a trial aspiration can be made by withdrawing the plunger before starting the injection then if blood appears in the barrel the position of the point of the needle can be altered and a further trial made When a wide area is being infiltrated some other method must be relied on The risks of accident are negligible if —

(1) The needle is kept on the move the whole time but quite slowly and smoothly so that the point slips past a vein instead of puncturing it Anyone who is accus-

[1] Sometimes it is the adrenaline and not the anæsthetic that the patient is sensitive to

sensitivity Intestine can be pricked or cut without disturbing a conscious patient, an exteriorised loop can be opened up with a red-hot cautery without the patient being aware of what is happening unless he notices the smell of burning It is only when intestine is crushed or dragged that pain is experienced, so it is possible to do a lot of surgery inside the abdomen with no anæsthesia at all

Clinical Experiment Much valuable information has been gained with the help of local anæsthesia The observation that vaso-dilation developed in the area of its distribution when the ulnar nerve was blocked at the elbow threw new light on the anatomy of the sympathetic system Formerly it had been believed that the vaso-dilator fibres travelled along the walls of the arteries, now it became clear that their real route was along the nerve trunks This discovery has proved of immense importance in sympathetic surgery The surgeon who contemplates a sympathectomy still relies on local anæsthesia for his pre-operative tests, by anæsthetising the ganglia with procaine he can anticipate the effects of surgical ablation and judge whether it will be beneficial or not These methods show a great advance on the days when a clinician sectioned a nerve in his own forearm in order to study the result

Some of the vagaries of visceral sensitivity have just been mentioned Anyone who is accustomed to open the abdomen under local anæsthesia will soon realise that there are many more, and may find important clinical applications for the knowledge he acquires But a great deal remains to be explained Why, for instance, is the shoulder tip pain which sometimes accompanies a perforated ulcer abolished by the injection of procaine under the skin of the shoulder? If we knew the explanation of this phenomenon we should be well on the way to under-

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tomed to doing veno-punctures know that something of a jab is needed to get through the wall of a vein

(2) The injection is never interrupted, so that a constant stream of fluid clears a path for the point of the needle

The presence of local anæsthesia in the tissues is apt to puzzle the novice, but to the experienced surgeon it is a help and not a hindrance Some surgeons, in fact, employ it for the express purpose of opening up tissue planes The exposure of the thyroid gland, for instance, is greatly facilitated by the injection So is the isolation of the ducts and the detachment of the gall bladder from its bed during a cholecystectomy And the separation of a Thiersch graft may prove less difficult under a local than a general anæsthetic Another advantage can be claimed for this form of anæsthesia—it enforces gentleness So the heavy-handed can resort to it as a corrective [1]

The Wrong Injection Anæsthetic solutions are colourless and, unless special precautions are taken, the danger of confusing them with each other or with other colourless

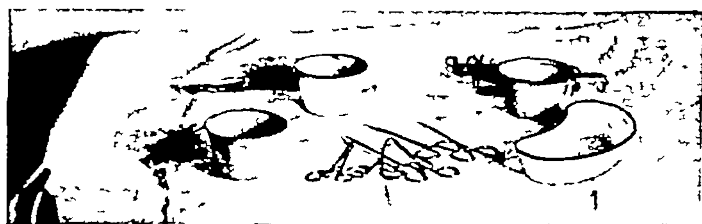


FIG 177 One gallipot contains spirit, another contains saline, and another novocaine Apart from the smell of the spirit there is no means of distinguishing between them

fluids is so great as to become an ever-present threat to the patient Alcohol, saline, intravenous anæsthetics have all been injected at one time or another in place of novocaine There are many ways of guarding against mis-

[1] Another remedy for this failing is to change to a smaller set of instruments, or watch a plastic surgeon at work for a session or two

takes. A colouring agent can be used This method has the advantage that the tissues are stained with the injection and the surgeon can see exactly how far his infiltration has gone Or the local anæsthetic can be taken from its labelled container directly into the syringe Or it can be decanted into a container with a special distinguishing mark.

There are other sources of error

Case Note (From a daily paper) DOCTOR TAKES THE BLAME At an inquest on Dr said he had ordered the hospital dispenser to prepare a solution of procaine but she misunderstood the telephone message and prepared a solution of cocaine instead.

Here the blunder was caused by similarity in nomenclature Other catastrophes are due to using solutions of a wrong strength

Case Note During the war two young soldiers were operated on for hernia under spinal anæsthesia Both developed paraplegia. One died shortly afterwards the other lingered on for nine months

It was assumed that the wrong injection had been given but no proper investigation was carried out The real explanation only came to light many years later when a similar mishap led to an action at law Experts of all kinds gave evidence including representatives of the drug firm In the course of the proceedings it was suggested that if an ampoule were cracked some of the antiseptic in which it was stored might find its way inside Experiments showed that this might well have happened Since then it has become a rule always to autoclave these ampoules

There is another way in which an injection can become contaminated by antiseptic A rubber capped bottle is sometimes dipped in spirit to sterilise it If the cap has been punctured before there may be a partial vacuum

inside and there is a possibility that spirit may be sucked into the bottle The multi-dose container has other drawbacks, not least of which is that it usually outlasts its sterility

Our knowledge of local anæsthesia has advanced greatly since Halsted first experimented on himself (and his assistants) with cocaine Many problems nevertheless, still remain unanswered No doubt time will alter this Meanwhile the following questions are worth considering

Why do manufacturers make so many ampoules of the same size and shape? Stick-on labels have mercifully gone, but why is the engraving on the ampoule so difficult to read? Could it be improved by eliminating everything except the name and dose? Why do theatre sisters sometimes store such different drugs as nupercaine and curare in the same jar? Why do medical officers sometimes omit to check an injection before giving it, and nurses fail to watch the patient while it is being given?

CHAPTER XXV

PLASTER OF PARIS

PLASTER of Paris is known commercially as gypsum and is in fact anhydrous calcium sulphate In surgery it forms the basis of the plaster cast which is steadily supplanting the splint as a means of immobilisation the cast nine times out of ten being a better fit more comfortable and a great deal more secure than any splint

Such a cast is most conveniently constructed of plaster bandages and these may be either factory made or home made The factory made have the advantage that the plaster in them is distributed with perfect uniformity from one end to the other and shows little inclination to drop out of the meshes Against this is the fact that it dries quickly so that it is likely to give trouble unless the cast can be completed in a short time And there is also the matter of expense which is much less if the bandages are made on the spot For a broken finger or wrist therefore factory made bandages will probably be the choice for a spinal jacket home made

To make a Plaster Bandage. The bandage should be of book muslin sized with starch to keep the plaster in place The impregnation is best carried out in a shallow tray containing a heap of plaster A bandage is rolled from one end to the other of this like a film in a camera and as it travels across the centre plaster is spread over it finely and evenly either with the side of the hand or with some form of spatula The spreading is something of a skilled job and one which needs experience After a while however it will be found the process becomes automatic

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grip of the hairs this does not inconvenience the patient because the grip is uniform and the hairs come away of their own accord long before the time for removing the cast Whether stockinet is used or not the bony prominences should always be covered with strips of adhesive felt



FIG 178 Nurse (a) gets rid of the surplus water by squeezing the bandage from end to end. (b) Unfolds one end before handing it over to the surgeon

Soaking the Bandages The successful construction of a plaster cast of any size depends on team work and not least important of the team is the nurse who soaks the bandages It is her job to see that the surgeon is never kept waiting for a bandage when he wants it and this involves something more than filling a bucket of water with bandages and handing one over when it is required. Setting is a chemical process unrelated to drying and bandages left too long in

Until this stage is reached a rough check can be kept by weighing the bandages when they are finished The following figures will serve as a guide —

Bandages 6 yd	long by	4 in	wide should weigh	9½ oz
,, ,,	,,	6	,, ,, ,,	14 ,,
,, ,,	,,	8	,, ,, ,,	17 ,,

The distribution of the plaster is not the only difficulty Rolling the bandage to the right degree of tightness is equally important If it is too tight the water will not wet it , if it is too loose it will spill out from the middle while it is being put on and have to be thrown away

To Pad or not to Pad A skin-tight plaster gives much better immobilisation than one put on over layers of cotton wool , and provided that proper care is taken to protect the bony prominences from pressure, and there is no likelihood of the limb swelling later on, it is just as safe When, however, there is any possibility of further swelling, as with a recent fracture, padding should always be used Padding is also needed in the operation case, especially when the operation has been conducted under tourniquet control If no room for expansion is allowed within the cast in such a case trouble is almost certain when the tourniquet is released and the vessels refill with blood So narrow is the margin of safety that splitting of the cast along one side is practised as a routine in many clinics

It is for the " change-of-plaster " case that the unpadded plaster is most suitable The patient may now be using or walking on the injured limb and a good fit becomes really important, a slackly fitting, loosely padded cast being a fertile source of sores from chafing and friction

The skin tightness can be modified by a layer of stockinet, but some surgeons prefer to put the plaster directly on the bare skin, and deliberately refrain from shaving or vaselining the part so that the bandages take a

measured length Nicks are then cut on either side where the joint will lie and the slab is ready to apply

A slab can be fashioned before or after wetting but with home made bandages it is better to do it after because then the plaster is less likely to drop out Care should be taken however to see that the slab is still quite wet when it is applied to the limb otherwise it will refuse to adapt itself smoothly to the contours of the part and sores may result later on

The Making of the Cast It takes many pairs of hands to make a big cast and they must all be fully occupied from beginning to end one or more to hold the part in position one or more to apply the bandages and one or more to mould them firmly into place

The way in which the part is to be fixed will vary with the circumstances of the case but as far as possible neighbouring joints should be left either free or if they must be included in a neutral position *e g* the wrist straight and the ankle at a right angle There is a temptation to use mechanical means to maintain whatever alignment is required but these often have their drawbacks At all costs whatever supports are employed whether the hand or some kind of sling they must not indent the plaster If a limb is held by an assistant movement must be guarded against because it may result in ridging or weakness of the cast opposite a flexure Later on during the drying stage the plaster may become indented if it rests on a hard surface the heel piece is easily flattened against the os calcis in this way

The bandages should fall easily and smoothly into place with no tightness but with no slackness either and one turn must follow another without leaving any interval for drying It is useless to lay a wet bandage on top of a semi-dry one because it will not adhere to it The business therefore must be got through without waste of

water will set as solidly as they might have done on the cast The optimum period for immersion finishes when all the air bubbles have been given off If nurse can time this period accurately so as to have the bandage ready just as the last turns of the previous one fall into position on the cast she will have done nearly all that is expected of her It only remains to squeeze out the surplus water (from end to end, not sideways, so as not to squeeze out plaster as well as water) and deliver the bandage with its last few inches unfolded and ready for use

Setting can be accelerated by using hot water instead of cold, or by adding common salt in the proportion of a drachm to a quart But since rapid setting is more of a handicap than anything else, these measures are seldom necessary

When a bandage is wound round and round a limb there is always a danger that it may be pulled too tight When this happens a sore may develop underneath Worse still, if the constriction is circumferential, the distal blood supply may be impaired, or even cut off

Because of this danger more and more surgeons are coming to use plaster slabs instead of encircling bandages for the construction of casts If such a slab is applied to one or other aspects of the limb and held in place by no more than a few turns of ordinary gauze bandage the possibility of any constriction is entirely eliminated This arrangement usually gives sufficient immobilisation for fractures round the wrist and elbow In the leg something more is needed, and the immobilisation can be improved by applying two slabs, one back and one front, and binding them together with a plaster bandage which should not, however, exert any more pressure than is needed to keep them snugly in place

The slabs are made from an ordinary plaster bandage by folding it backwards and forwards on itself to a

well away from the level where it might crush the peroneal nerve as it crosses the head of the fibula.

Pressure Points Some of the areas which are exposed to pressure are listed here —

In the arm	Acromion Internal epicondyle Olecranon and subcutaneous border of ulna. Ulnar styloid
In the trunk	Sacrum and vertebral spines of bed patients Crest and spines of ilium
In the leg	Head of fibula Both malleoli Dorsum of foot Heel.

Over these areas skin lies very close to bone and can easily be compressed against it but in a thin emaciated subject a sore may develop almost anywhere

Reinforcing a Plaster A plaster can be reinforced by incorporating lengths of wood or tin or by using additional slabs over the flexures where the risk of cracking is greatest or by plucking the plaster up into ridges at right angles to these flexures With a spica for shoulder or hip the limb can be buttressed from the trunk or the opposite limb by a plaster bandage

After Care Plaster sets of its own accord no matter what the conditions but drying is expedited by heat and a free circulation of air A heat cradle will provide both of these and should be used as a routine a wet plaster is uncomfortable and chilling to the patient so the sooner it is dry the better

The limb should be elevated as high as possible inside the cradle Even with this precaution some swelling is

time, and this is one of the reasons why plenty of help is required Another is the need for constant moulding Moulding not only gives a good fit but it ensures homogeneity If each turn of bandage is closely applied to the preceding one, with no air bubbles in between, the cast will possess a lightness and strength that can be achieved



FIG 179 Nicking a slab at the ankle It is put on with the patient prone so that the foot remains at right angles to the leg of its own accord

by no other means So any member of the team who finds himself with an idle moment should occupy it with moulding, using the palms of his hands, not the finger tips, and giving special attention to the bony prominences, where an exact correspondence is all-important

When the cast is complete its edges should be trimmed to clear any adjacent flexures, and if stockinet has been used it can be turned back to give a smooth finish and protect the skin from any roughness or irregularity Special care should be taken to keep the edge of a leg cast

CHAPTER XXVI

KNOTS

FORMERLY a surgeon was expected to have as many knots at his finger tips as a boy scout now he is often

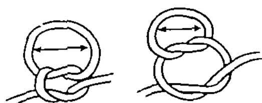


FIG 181 A reef knot and a granny the tension shown will tighten the first but open the second.

content with one This should certainly be a reef or square properly constructed with the loops lying snug and close so that they hold firm The more a well made reef is pulled on the closer it binds Pulling on a granny or a spoilt reef rolls the loops over and over until the ends come apart What happens can be demonstrated quite easily by a few simple experiments with knots tied in a rubber band A reef is spoilt (*i e* turned into a slip) by tugging unequally on one or other end (Fig 182) Even failing to relax tension on the strands between the hitches so



FIG 182. A reef tugged into a slip

that the tightening of the second hitch disturbs the lie of the first is enough to upset the knot One handed knotting is therefore undesirable *if it means that one strand is held taut the whole time* Ligaturing from a spool or long

almost inevitable (unless the plaster is a replacement), and this will cause most patients a certain amount of discomfort during the first twenty-four hours. Genuine pain is a different matter. If it is localised it means that a sore will develop unless a window is cut to relieve



FIG. 180. Ridging a slab to reinforce it.

pressure. If it is generalised it nearly always means a dangerous constriction and a threat to the circulation. The exposed extremity will soon be blue, cold and insensitive if the cast is not split so that skin is seen from end to end. Not all these cases go on to gangrene, but even if the urgency subsides the patient may well be left with an ischæmic contracture of his muscles as a result of the interference with their blood supply.

but it is bad practice to allow oneself to get into the habit of using it in case it may be inadvertently employed for a large artery or vein

The surgeon's knot (Fig 184b) is designed to prevent the first hitch from slackening before the second closes down on it But it defeats its own object because the first double hitch prevents the second from falling comfortably into place and this leaves the way open for slackening later on The same end can be attained more satisfactorily by getting an assistant to grip the first hitch with a dissecting forceps (non toothed to avoid fraying) until the knot is completed

The other type of knot once popular for large vessels is the stray (Fig 184a) It was thought to give greater security and wider occlusion but it is probably safer to rely on two reefs side by side

The Material Used. As every fisherman knows a knot weakens a line not only because it may loosen but because the tying of it may cause fraying—witness the

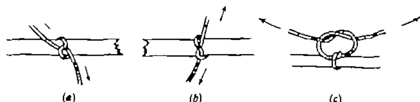


Fig 185 (a) A bad start fine material would snap under the cross pull ligature catgut is wasted by the yard in this way (b) Better, this is the first hitch of what the Americans call a flat knot (c) Second hitch in a different plane to first this will never make a flat knot.

frequency of a break during the actual knotting Anything in the way of cross sawing (Fig 185a) increases the risk a hundredfold and this is perhaps the strongest argument of all for accurate tying It is not however an excuse for using stronger material Stronger material is almost always bulkier too and bulkiness is incompatible with a close lie So is wiriness On the other hand undue

strand is open to a similar objection For security, a two-handed knot, tied from a fresh 14- or 15-in length, with each hitch deliberately set by the tips of the index fingers, is ideal, cutting the ends reasonably long is an additional safeguard, but leaves more material to be absorbed

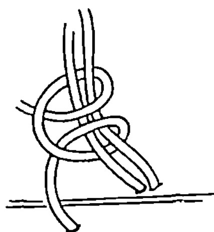


FIG 183 A knot at the end of a suture line tugged into a slip

An assistant should never pull a continuous suture taut until the second or third stitch has been inserted Otherwise he may "spoil" the knot Since we know that many ventral herniæ are due to the giving way of suture lines, a detail like this may be quite important (Fig 81)

A knot at the end of a suture line is made with three strands instead of two, and this tends to interfere with the set, moreover, it is easily "spoilt" (Fig 183) A third hitch, made exactly like the others is then an advisable safeguard

Some Bad Knots Knots subject to constant or intermittent pull are the important ones A granny knot is unlikely ever to give way once it is tied on a small vessel,

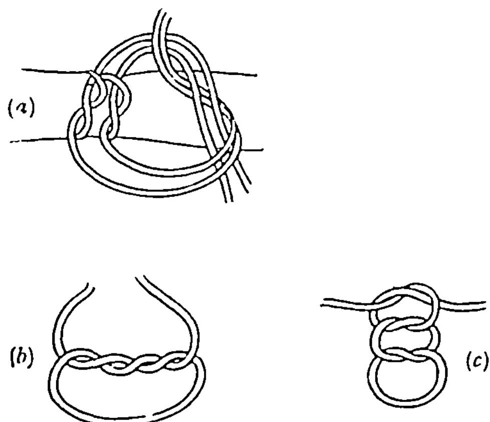


FIG 184 (a) A stay knot (b) A surgeon's knot (c) A triple throw knot

sawing avoided *both loops must be tightened in the same plane* (Fig 185c) Wherever possible this plane should be the one at right angles to the surgeon and not the one parallel to him The hands can be moved backwards and forwards in tying a knot with the greatest of ease

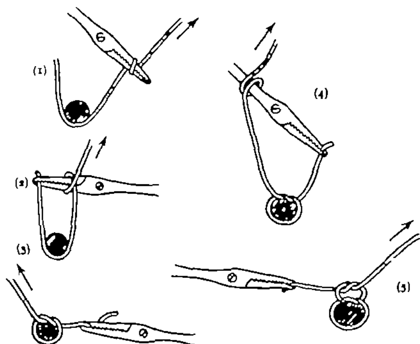


FIG 186 Tying a knot with artery forceps. (1) Holding the long end of ligature with fingers or Spencer Wells, a hitch of it is wound round the beak of another Spencer Wells. (2) This Spencer Wells is swung round and the short end of the ligature drawn through the loop so formed (3) The first hitch of the knot is tied (4) A hitch of the long end is again wound round the beak of the Spencer Wells, and the short end again drawn through it (5) The second hitch is tightened. Note the reversal of the first and second hitches over the Spencer Wells. This gives a reef knot

not so from side to side A moment s trial will make this abundantly clear

The photographs illustrate one-handed two-handed and forceps methods of tying knots Needless to say if they are used for practice the knot should be tied in the plane shown in the picture which is being copied otherwise only

flexibility—as of plain catgut—abolishes frictional grip, and greatly reduces the reliability of a knot

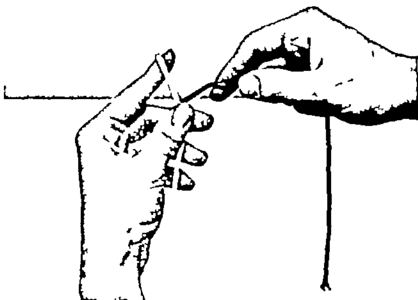
Other things being equal, security depends on this frictional grip between the strands of the knot Fortunately it is greater when the suture, whether absorbable or unabsorbable, is moist than when it is dry The action of the tissue fluids is, accordingly, advantageous from this point of view But there are drawbacks in the case of catgut, which swells and becomes elastic in the presence of moisture These changes must be counted on the debit side of the safety account

When all is said and done it must be concluded that plain thread or silk gives the best knots A triple-throw reef with either of these give 100 per cent protection against slipping If the silk is coated to make it impermeable an element of danger creeps in

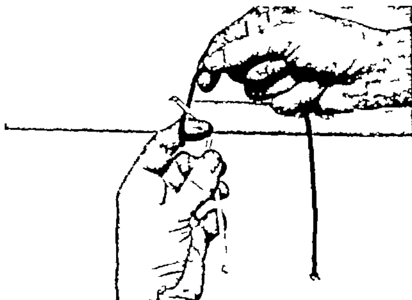
Knot Tying Not a few surgeons go on tying slip knots all their lives without realising what they are doing Others only fall from grace in moments of stress But a little practice (not on the patient) is all that is required to ensure correctness and uniformity in this matter After all, it is only necessary to learn how to tie one knot, even though it may have to be done in several different ways

A reef can be tied by dropping the ends and changing hands before making the second loop, but this method is slow and cumbersome It can be tied by holding one end in the left hand and tying the knot with the right, or *vice versa* , the objection to this method has been mentioned It can be tied with both hands, and this is the surest way of getting uniformly good results Or it can be tied with one or two artery forceps, when a no-touch technique is essential, when one or both ends are too short to handle, or for reasons of inaccessibility

The importance of good " set " in a knot has already been stressed To ensure that it is obtained and all cross



F o 188 (a) White strand held between thumb nd second finger of left han l with index finger elevated as bridge Black strand held between thumb and ind x finger of right hand



I IG 188 (b) Di tal phalanx of left index passed under black stra d upported in right hand and over white strand.

confusion can result Notice that the one-handed and two-handed knots can each be started with either the right hand or the left hand That there should be four different ways of tying the same knot undoubtedly makes

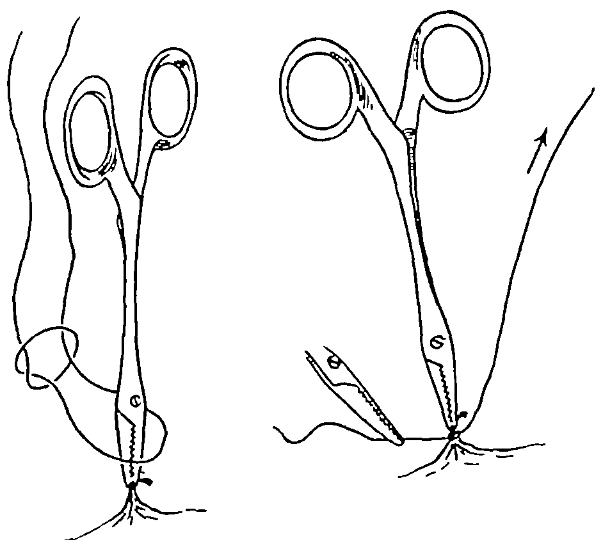


FIG 187 To ligature a deep vessel slide a slip knot over an artery forceps Tighten with another forceps and complete the knot after removing the first forceps

for confusion, and very close attention is required at the outset if it is to be avoided But after a while the movement of the fingers becomes automatic, and a perfect knot is produced with effortless ease, no matter in what circumstances

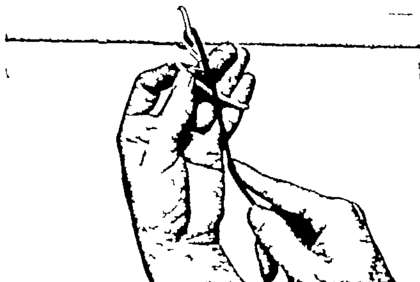


Fig 188 (e) White strand looped round three fingers of left hand and distal end held between thumb and index finger Black strand held in right hand and brought over white strand

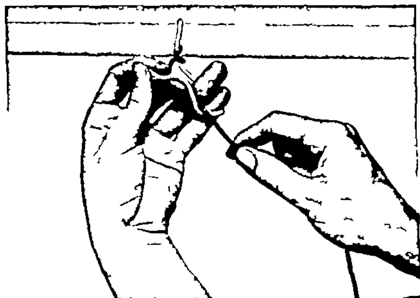


Fig 188 (f) In t l phala of left second fi er i fle ed thus pa g black t d f rw rd d bene th whit tr d I p f se and fi e of left hand i extended so that whit strand i brou ht b hind it

FIG 188 (c) Left hand rotated inward by pronation and white strand pulled through loop by extension of left index finger

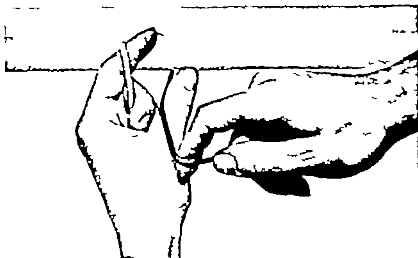


Fig 188 (i) White strand placed over extended index finger of left hand acting as a bridge and held in palm of left hand Black strand held in right hand brought between left thumb and index finger

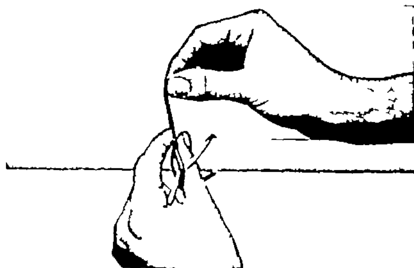


Fig 188 (j) Left hand turned toward pronation and thumb pushed under white strand Black strand crossed over white and caught between thumb and index finger of left hand

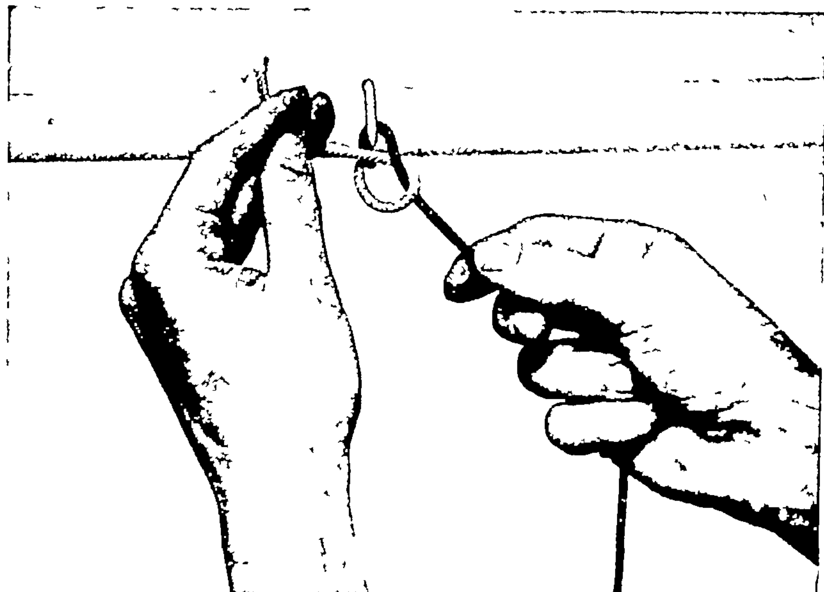


Fig 188 (*g*) Left hand is rotated inward by pronation, and second finger of this hand extended to bring white strand through loop

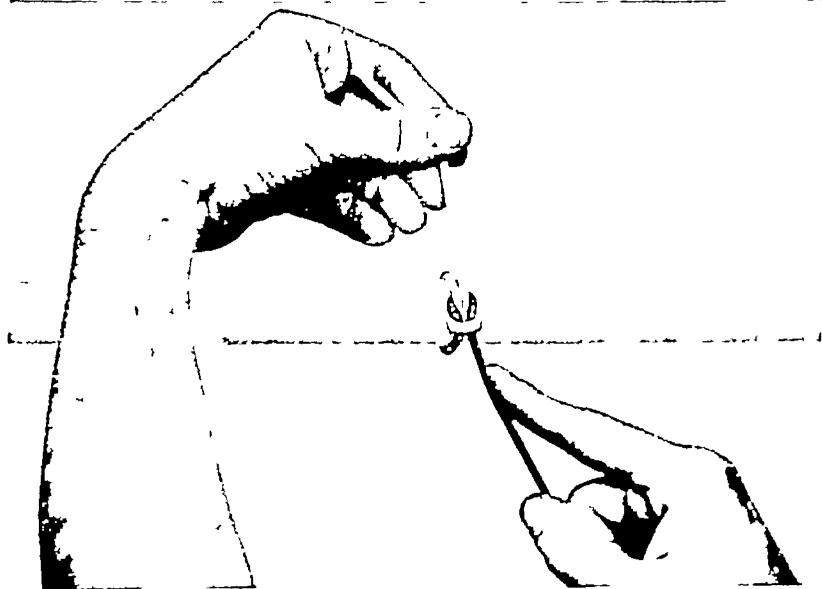


Fig 188 (*h*) Square knot completed by horizontal traction Left hand away from and right hand toward operator

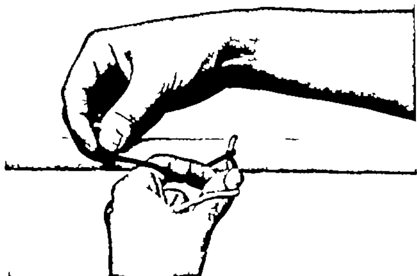


Fig. 188 (m) Left hand turned inward by pronation and black strand placed in angle between left thumb and index finger. Index finger is then flexed over black strand and placed beneath thumb.

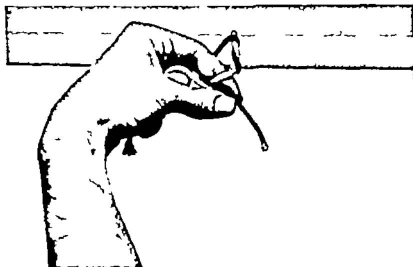


Fig. 188 ([illegible]) White strand held on to index finger of right hand; black is placed over white and grasped by left index finger and thumb.

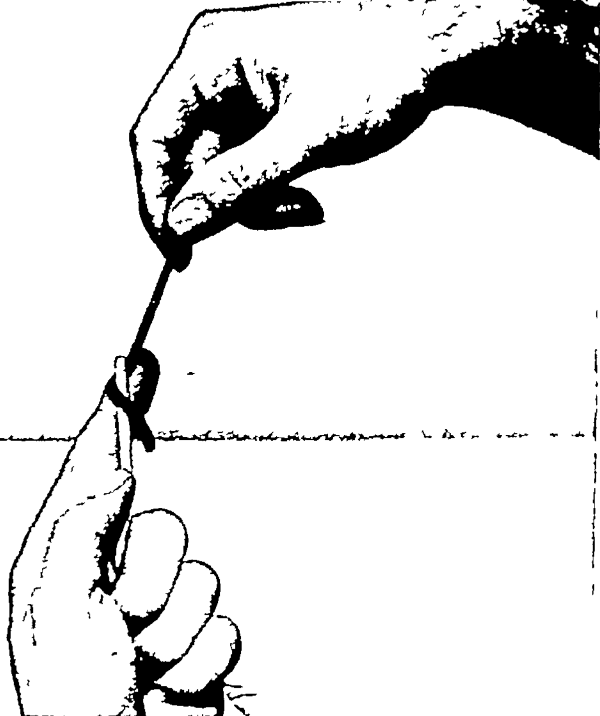


FIG 188 (*k*) Left hand turned outward by supination with thumb and index finger still grasping black strand and pushing through the white loop Black strand is released by left hand and grasped by right



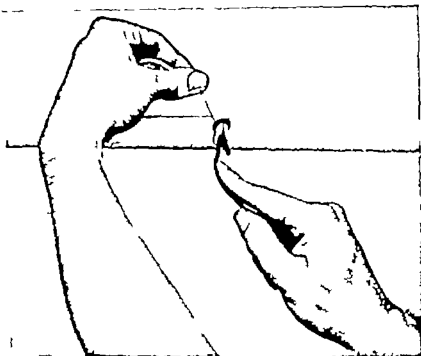


Fig. 188 (q) Hands in reverse position and horizontal traction applied with left hand away from and right hand toward operator

(*These photographs are reproduced by courtesy of Ethicon Suture Laboratories.*)

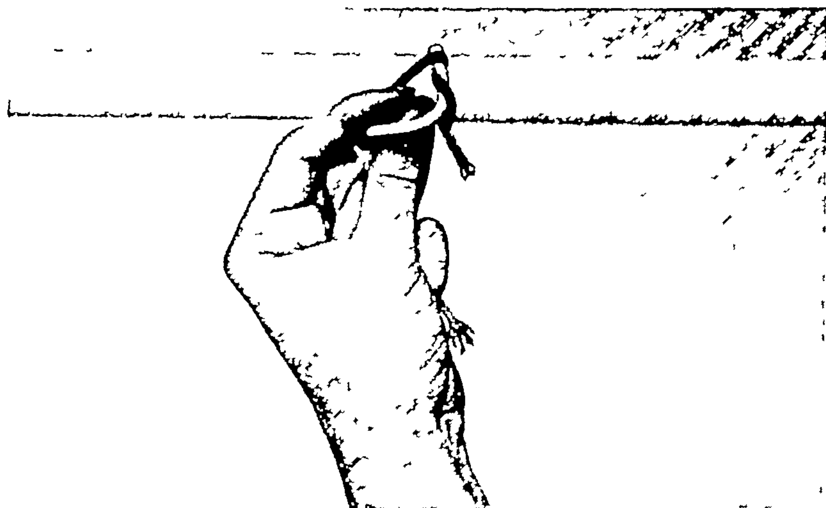


FIG 188 (*o*) Left hand rotated inward by pronation with thumb carrying black strand through loop

FIG 188 (*p*) Black strand released from left index and grasped by right hand Second half hitch is completed by reversing position of hands – black strand remains in right hand and white in left

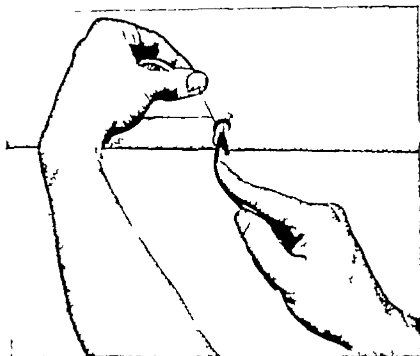


FIG 188 (q) Hands in reverse position and horizontal traction applied with left hand away from and right hand t ward operator

(These photographs are reproduced by c urtesy f I thicon Suture Laboratorie)

CHAPTER XXVII

SUTURES AND STITCHES

It seems fairly certain that in the long run absorbable sutures will supplant all others for internal use Recently there has been a swing in the opposite direction because present-day catgut is unreliable in many respects, but this can only be a temporary phase which is bound to pass when manufacturing methods improve

Sterilisation of Catgut Catgut [1] is obtained from sheep's intestine in the same way as sausage skins by scraping off the mucous and muscular layers The remaining tough and durable sub-mucosa is then split into ribbons, and two or three of these ribbons are twisted together to form strings of the calibre required for the gut

Formerly sterilisation was carried out by two or three weeks' immersion in a jar of antiseptic Cultures were then made without taking the precaution of thoroughly eliminating the antiseptic or of separating the ribbons Everyone was satisfied with the results of these tests, but in actual fact the antiseptic solution never really penetrated the strings, and many wound infections followed their use Even cases of gas gangrene were reported

The whole business is now under Government supervision, and strict testing and licensing are necessary before the product can be put on the market

Sterilisation is by heat, and only dry heat can be used, because in the presence of water, or indeed the least trace of moisture, heat will convert the collagen of the gut into gelatin, all tensile strength being lost at once Thorough drying is therefore an essential preliminary to the process,

[1] Catgut is a corruption of kitgut, a kit being a fiddle

and this dryness must be maintained until the sterilising is complete The finished strands are then wound on reels and put up in *sealed ampoules of a solution which* may or may not contain a small proportion of water

The exterior of these ampoules must be sterilised before they are laid out on the theatre trolley and it is over this step that confusion sometimes arises The ampoules containing completely anhydrous fluid can be boiled the others cannot—if they are the heat will bring about *the collagen to gelatin transformation* and ruin the contents Catgut taken from a boilable tube tends to be hard and brittle so that it is clumsy to stitch with and difficult to knot Its pliability can be restored by dipping it for a few seconds in saline or a few minutes in 75 per cent alcohol. This should be done before it is unwound *otherwise it may crack as it comes off the reel* It is a mistake however to overdo the soaking Limp catgut cockles up in a most embarrassing way and is just as difficult to work with as wiry

But the non boilable ampoules are becoming increasingly popular and may soon oust the other variety altogether They are sterilised by immersion in a jar of antiseptic for eighteen to twenty four hours

Absorption of Catgut The following times for the absorption of plain catgut are taken from experiments on the guinea pig —

In muscle	7–15 days
In intestine	2–4

But when the cutgut is treated with chromic acid absorption is slower —

In muscle	20–30 days
In intestine	5–10

But what happens when catgut is buried in the tissues of a human being no one can exactly say The fact that

it sometimes disappears almost at once and sometimes lingers on for years suggests that individual peculiarities play so large a part in its fate as to preclude any simple answer to the question

The Americans are content to use a laboratory method for standardising their catgut They suspend a strand in a solution of enzymes at constant tension and temperature When the proteolytic action of the enzymes dissolves the strand an electrical circuit is broken and the interval that has elapsed is recorded by the hand of a clock This technique gives a reliable basis of comparison, but the conditions are artificial, and the resultant grading cannot be regarded as having any clinical significance

Painful experience teaches us that non-chromicised catgut disappears very quickly from a wound By the end of four or five days its holding power has almost gone, although healing can hardly have begun It should therefore be employed only to a very limited extent It is suitable for tying off small vessels and suturing mucous membrane It is unsuitable for intestinal anastomosis, the intestinal juices dissolve it too quickly It *must* be used for all suturing in the urinary and biliary tracts In these situations rapid absorption is eminently desirable a suture which survives for any time and is exposed to action of urine or bile may easily become covered with salts and form the nucleus of a stone

Case Note A patient complained of pain a few months after a pyelolithotomy X-ray showed a shadow in the position of the pelvis A year ater a stone anchored by a piece of catgut was removed

Contrast with this, however —

Case Note The supra-pubic wound disrupted shortly after a prostatectomy It was discovered that non-chromicised catgut had been used throughout the operation because " it was a bladder case "

The surgeon who finds himself closing the abdominal wall with a piece of catgut which hangs quite limp or winds itself into a tangle when there is any slack should enquire what he is working with before he goes any further It may be a length of chromicised catgut that has been soaked for too long or it may be plain catgut in which case it had better be changed for something more durable

There is another count against plain catgut Not only does it disintegrate quickly but it leaves behind it a considerable amount of debris Apparently chromic gut is invaded slowly and digested thoroughly by the giant cell whereas plain gut is attacked by the polymorphs and never properly assimilated If the plain gut belongs to one of the thicker grades trouble may ensue

It follows from all this that chromic gut is the stuff for serious suturing Whether it really lasts as long as is claimed for it or not there can be no doubt that it is much better than the plain and that it is the only type to use for closing the definitive layers of a wound of any magnitude

Infection and Absorption of Catgut It seems that a mild degree of infection does not affect the rate of absorption of catgut But with a severer degree the gut may be attacked by leucocytes and quickly destroyed Not only this but the tissue destruction caused by the inflammation will facilitate cutting out so there are two factors militating against sound healing in an infected wound Fortunately inflammation seldom gains much headway before catgut has fulfilled its function of bridging the time interval between incision and commencing repair It is worth noting that in two series of cases of wound disruption the infected cases disrupted later than the non infected

Delayed Absorption of Catgut. In practice the surgeon

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Living Sutures The living suture made from fascia taken from some other part of the body and used to replace a tendon or missing ligament close a hernial orifice or lend support to paralysed musculature was popularised by Gallie in the early nineteen twenties The ilio-tibial band supplies the material in most cases but sometimes the tendons of palmaris longus or plantaris prove more suitable

It is found that fascia obtained in this way and interlaced between the margins of a hernial defect becomes welded into the tissues by a fibrous reaction although the

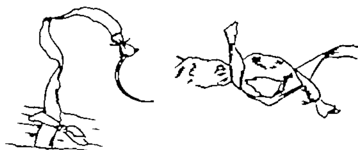


FIG 190 Starting a fascial suture and linking one fascial suture to another Fascia is slippery stuff and must be firmly anchored with all knots secured by non absorbable sutures these sutures must pierce the strips and not merely embrace them

transplanted strands can still be identified after the lapse of many years Meanwhile the composite mass of scar tissue and transplant forms an effective barrier against recurrence of the hernia But if a strip of the same fascia is transplanted into a part of the body where it subserves no function and is subjected to no strain it is soon absorbed

The palmaris longus and plantaris tendons can well be spared by the hand and leg and even the removal of part of the ilio-tibial band leaves no permanent disability It is true that the vastus externus bulges through the gap immediately after the operation but as time goes by the aponeurosis gradually fills in from either side so that

has more to fear from delayed absorption than accelerated absorption It will be remarked that in the recurrent stone case described above the catgut showed no evidence of absorption after the lapse of a year, perhaps because it was to a large extent protected by the deposit around it But it is not unknown for sutures to survive in other parts of the body for even longer periods for no apparent reason The bulkier kinds of catgut (because of the uncertainty in grading these are not necessarily the twos and threes) are the greatest offenders in this respect, so also are clumsy knots with ends left long

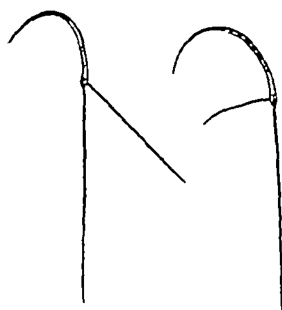


FIG 189 A curved needle is less likely to become unthreaded if it is threaded from within out than from without in

Grading of Catgut Catgut is calibrated in increasing thicknesses —

0000, 000, 00, 0, 1, 2, 3, 4

For reasons already given it is no longer customary to talk about ten-, twenty- or thirty-day gut Most of the firms classify it as soft, medium and hard after chromicising In recent years no really plain catgut has been manufactured, even the non-chromicised variety is always hardened to some degree by the processing

Kangaroo Tendon This is obtained from the tail tendon of the kangaroo, and prepared for use much in the same way as catgut, even to the final chromicising It lacks pliability and may need to be soaked in saline for as long as thirty minutes before it becomes manageable Absorption is slow, which may be desirable in some cases, but surgeons nowadays have many other resources to call upon when catgut does not meet their requirements, and kangaroo tendon has lost what popularity it ever enjoyed

Non absorbable Sutures and Stitches The choice of non absorbable sutures and stitches steadily widens All have the advantage over catgut of being sterilisable by heat either in the steriliser or the autoclave At the same



Fig 191 Silk unravelled to show the interstices.

time it does not improve them to repeat the sterilising process over and over again Once properly sterilised it is better to keep them so by storing them in antiseptic until they are required A 1/20 solution of carbolic is reliable for this purpose Spirit reduces tensile strength and should not be used

Silk is obtained from the cocoon of the silkworm after the worm has been killed by heat When the delicate threads are unwound from the cocoon they are twisted plaited or braided to the required size and length

The drawback of silk is its irritant action on tissue and its permeability which enables it to harbour discharges and perhaps act like a wick conducting infection from one part to another There is a risk of this happening when it is employed for tension stitches because these put the surface of the skin in direct communication with the depths of the wound And in the deeper layers it should only be used in 100 per cent clean cases if it is used in an infected case a sinus may form which will not heal until the foreign body comes away Silk is now prepared by some firms with a coating that renders it impermeable This gets over the drawback of permeability but unfortunately the coating makes it quite slippery so that a triple hitch is needed for all knots

Linen thread is open to the same objections as silk and its tendency to cling makes it difficult to handle and easy to leave behind in the wound This last oversight is less

eventually the defect entirely disappears So complete is the regeneration that fresh strips have actually been taken from the same site after the lapse of some years in order to carry out another repair This regenerative capacity is important to the surgeon in another way When he finds himself closing an incision in an aponeurosis overlying muscle under tension, *e g* , in the anterior rectus sheath, he need have no hesitation in making lateral cuts to relieve the strain they will close of their own accord in just the same way that the ilio-tibial band does

In preparing a graft of this kind the living sutures must be cleared of all fat and cellular tissue, both of which are likely to interfere with " take " , no rough handling is permissible in doing this Some surgeons insist on a " no touch " technique throughout , whether it is adopted or not, very special precautions must be taken against any risk of infection The newly transplanted strips are in a parlous state for a week or two, and infection may easily lead to their death If they do die the patient is left with a wound which continues to discharge until they are thrown off or deliberately removed

The other method of fascial grafting, using a patch cut to fit the defect, has not met with much success The patch, even when there is a generous overlap, can be nourished only from the periphery, and its chances of survival are not great Oddly enough the patch technique for repair seems to give better results when the material used belongs to an entirely different class Scraped skin and whole skin have both been employed to strengthen the posterior wall of the inguinal canal Whether the epidermis is removed or not appears to make very little difference The epithelial and glandular cells disappear in any case, leaving a dense mat of connective tissue adherent to the muscle above and the ligament below, and this prevents recurrence of the hernia

must inevitably vary a lot in size and it cannot be obtained in lengths of more than 12 to 14 in Horse hair is brittle and short For these and other reasons artificial sutures are steadily ousting nature s handiwork in almost every branch of surgery

Nylon possesses almost all the qualities that the surgeon could ask for But it is quite slippery and should always be knotted with a triple hitch The braided variety is more reliable than the monofilament in this respect Carbolic destroys nylon so it must be stored in some other antiseptic solution

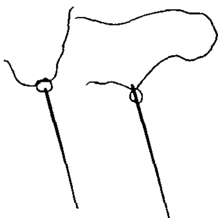


Fig 192 To prevent a stitch coming out of the eye of a needle this is particularly likely to happen with nylon because it is so slippery

Stainless steel wire is becoming increasingly popular as a suture material It can be used with an ordinary needle and for any kind of stitch It is completely impermeable and it excites not the slightest reaction in the tissues Its only disadvantage is that once kinked it loses all tensile strength and may snap on the slightest provocation so the greatest care must be taken to avoid doubling it back sharply on itself and all knots must be tied accurately without cross tugging The ends of the knots should be tucked away with an artery forceps so that no projection is left Some practice

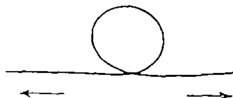


Fig 193 If a kink closes on a piece of steel wire it is left a brittle as horse hair

likely to occur if black thread only is employed Some surgeons use thread for suturing, others reserve it for ligatures

Cotton thread is much cheaper than linen thread It may be used for fine ligatures

Floss silk The gossamer fibrils of this material are readily invaded by fibroblasts, and it enjoys a reputation for the repair of hernia on that account It is prepared ready sterilised in ampoules, but should be well rinsed before use It is also available in spools which can be sterilised by boiling This material should never be soaked in antiseptic because of the latter's irritant effect on the tissues

Silkworm gut is used almost entirely for skin or tension stitches Like silk, it is prepared from the silkworm, but the worm is killed at an earlier stage in its life history, before the cocoon is formed A viscous fluid, forerunner of the silk, is then drawn off and allowed to dry The process is an elaborate and highly skilled one, and is the monopoly of a particular district in southern Spain There soil, climate and the inherited skill of the peasantry have built up an industry that no competitiors have succeeded in copying

Japanese gut is the only near imitation of silkworm gut It is produced by treating ordinary silk with glue, but has not been obtainable since the war

Horse hair was formerly used for cosmetic work, but nowadays the tendency for the plastic surgeon is to use a factory product

Strength, uniformity, impermeability, inertness and resistance to sterilisation by heat are things that must be compounded at the work bench Of the sutures already mentioned all are deficient in one or more of these attributes Silk can be twisted to the size required, but it is permeable Silkworm gut is impermeable, but it

fell through There is just as little uniformity in the grading of suturing and stitching material as of catheters and bougies and as little likelihood of any rationalisation in the near future but the following is fairly representative –

Silk	Braided white	00000	4
	Braided black	00000	4

Silkworm gut.	White	Fine medium stout
	Black	Fine medium stout

Nylon.	Gossamer	1N	Black
	Extra fine	2N	Blue
	Fine	3N	Purple
	Medium	4N	Green
	Strong	5N	Black
	Extra strong	6N	Blue
	Stout	7N	Purple
	Extra stout	8N	Green

In 14 and 30-in strands

Linen thread 100 90 60 40 35

Cotton thread 60 24.

Steel wire Standard wire gauge 34

Metal in the tissues Until fairly recently the metals available for surgical use all tended to undergo chemical change in the tissues. None was completely inert Nowadays stainless steel tantalum wire or gauze and vitalium in the form of screws or plates can be left in the body without any fear of untoward reaction Hernial weaknesses gaps in the skull and many other defects may be repaired with these materials without so much as a trace of tissue tarnishing Even if the wound becomes infected the inflammation often settles down in spite of the presence of a foreign body

This is undoubtedly a great advance and meets a long felt want The surgeon can now fill a gap a procedure

is needed before the trick of handling wire sutures is acquired

Grading Non-absorbable Stitches and Sutures. At a recent international conference an attempt was made to



FIG 194 A non absorbable suture was used between skin and bone to ligate a varicose vein on the shin, six months later the little wound was still scabbed

establish one universal scale of sizes for catheters and bougies and discard the many others now in use The representatives agreed to accept the Charrière as the best of the lot, but the French were against it, so the project

CHAPTER XXVIII

ANTISEPTIC ACTION

ODDLY enough the name itself does not make any great promises or exaggerated claims. Antiseptic says what it means and no more in plain unscientific language. The magic which has done so much mischief must have grown round it as the years went by. Ever since the dawn of medicine doctors have been searching for some substance that would bring about a *sterilisatio magna* that would stamp out the last trace of infection whether it was injected into the body or applied to an open wound. But it seems that this search is doomed to failure. What ever the laboratories manufacture the tissues will always have the last word. Ambroise Paré the man who put a stop to the practice of pouring boiling oil on amputation stumps summed the situation up four centuries ago when he wrote —

I dressed him God healed him

Character of an Antiseptic Before a chemical can be accepted as an antiseptic not only its action on bacteria but its action on the human body and its *action on bacteria in the human body* must be taken into account. Almost any chemical will kill bacteria if it is sufficiently concentrated. The problem is to find one that will do this without killing the living cells at the same time.

Phenol can be taken as an example. In the pure state it is an escharotic. But this did not prevent the surgeons in the early stages of the First World War from using it as an application to recent wounds—with disastrous consequences for the patients. In actual fact phenol is so destructive to tissue that solutions of it which are too

which is much more likely to give good results than the old one of dragging its edges together In the radical cure of hernia, for instance, the stitching of conjoined tendon to Poupart's ligament is probably waste of time , muscle pull cannot be permanently deflected in this



Fig 195 A silver filigree used to cure a hernia

arbitrary fashion , in all likelihood the sutures cut out within a few days At the Seamen's Hospital, Greenwich, all big herniæ are dealt with by inserting filigrees, which close the defect without introducing the slightest degree of tension anywhere The patient is out of bed the day after such an operation, and the results are good

retained for surface application irrigation of cavities disinfection of apparatus etc. Others are discarded altogether or relegated to domestic use Mummy says the little girl with the tear stained face where s the glozo?

Skin Antiseptics As a general rule it is a mistake to combine *spirit* with any other antiseptic. The coagulating power of the spirit on the tissues interferes with any penetrating power there may be in the mixture But this does not apply to skin disinfection Here fat must be dissolved before bacteria are destroyed and spirit does this very satisfactorily Not only this but by lowering surface tension it improves spread Anyone who has tried painting the abdomen with a watery solution knows how difficult it is to get an even distribution The bactericidal power of spirit is highest in a strength of 70 per cent and this is ideal for application to a dry skin A slight alteration in strength either upwards or down wards is enough to interfere with the action and therefore when the skin is moist from recent washing or sweating a stronger preparaion may be employed to counteract the dilution so produced.

Iodine is commonly dissolved in spirit in the proportion of two parts to a hundred As a colouring agent it certainly has the virtue of showing the surgeon which part is painted and which is not It is not so easy to be sure of its bactericidal advantages but reports from America are very suggestive The tests carried out consisted in counting the bacteria in water used for washing before and after swabbing the hands with various antiseptics Iodine in spirit reduced the bacterial count more effectively than anything else It is not suggested of course that a surgeon should use it each time he washes up it is much too irritant for that Nor should it be used haphazardly on the more sensitive parts of the patient s

weak to have the slightest effect on bacteria will eliminate phagocytes completely, pathologists are well aware of this property, and sometimes take advantage of it when they are preparing a blood culture Milder preparations than phenol may be inimical, without being lethal to cell life, and still hamper the efforts of the phagocyte, which is the real front-line soldier in the war against infection Or this hostility may be reserved for the later stages of repair, when the round cell begins to put in an appearance Then the formation of healthy granulations will be interfered with, and healing correspondingly delayed If antiseptics were not affected by contact with the tissues, and their action could be counted on to continue for any length of time, many difficulties would automatically disappear Initial concentration would not be necessary if prolonged activity were assured Solutions so dilute as to be certainly innocuous could be used in the confidence that they would have ample opportunity to do their work, and would in the end kill the bacteria without doing any harm to the host But these conditions do not obtain in the human body Most antiseptics are quickly diluted, and many of them combine with protein, thereby losing their efficiency at once

There are tremendous drawbacks, though subject to qualification in certain cases The halogen and oxygenator groups, for instance, act so quickly that the effects of dilution may be forestalled The dyes are absorbed, and presumably carry on their work for a little longer on that account Other antiseptics may be applied continuously on an irrigating system (though this is undesirable, as will be seen) But when all is said and done it must be admitted that most of the chemicals have had their day so far as the local treatment of infection is concerned Sulphonamides and penicillin have almost entirely ousted them Of the old-fashioned antiseptics some are still

sebaceous glands and hair follicles As long as they remain where they are they do little harm But vigorous scrubbing may have already liberated them and sweating will undoubtedly draw them from the depths That is why it is so important for the surgeon to see that he does not permit any exposure of the patient s skin until the wound is closed and that he does not carry on operating with a punctured glove

The New Antiseptics Penicillin is the first substance ever known that has a more powerful effect on bacteria than on cells Its toxicity is negligible but unfortunately it is very unstable and is easily and quickly destroyed Acids alkalis alcohols heavy metals oxidising agents heat and the lysins of some bacteria may each and all inactivate it The consequence of this is that it cannot be given by the mouth and even when injected must be handled with the greatest respect In the powdered form it keeps well but once dissolved it deteriorates rapidly Solutions must be kept in a refrigerator but even so their efficacy is lost in a matter of twenty four hours The procaine solution is an improvement in this respect It acts as a preservative and does away with the need for refrigeration

Every care is needed to see that not the minutest trace of an antagonistic drug comes into contact with penicillin while it is being prepared or given Special attention should be given to the sterilisation of syringes If these are taken out of a dish of spirit or out of a steriliser containing alkalinised water the way is paved for con tamination When penicillin is used topically all other antiseptics are tabu The sulphonamides are much more stable than penicillin and can be given by the mouth Unhappily they are also much more toxic

These drugs act specifically Certain organisms are sensitive to them and certain others are not Broadly

body—for instance, the scrotum Anyone who has made the mistake of splashing iodine or spirit on a conscious patient's scrotum will have no doubts about this In children this part of the body is even more vulnerable than in adults Prolonged exposure is another thing to be avoided An iodine swab used as a dressing after a veni-puncture will almost certainly cause a burn , so may iodine allowed to lodge in the umbilicus or pool on the table under the towels

Flavine and *picric acid* are also combined with spirit for skin disinfection Iodine in spirit acts quickly—" it disinfects while it dries " In contrast flavine is slow It may prove satisfactory when the preparation is done deliberately, twenty-four hours before the patient goes to the theatre, but it is not suitable for an emergency There is this to be said, however, in its favour—it enjoys a very high laboratory reputation in experiments conducted against the staphylococcus The published results of these cannot be ignored, least of all by the surgeon, who has most to fear from the staphylococcus

Picric acid has lost most of its popularity because of the very unpleasant reactions which sometimes follow its use

The *dyes*, of which, of course, flavine is one, are all germicidal even in high dilution, and are well tolerated by the tissues Perhaps the most popular of the lot for use on the skin is *Bonney's blue* Its formula is —

Crystal violet		5 per cent
Brilliant green		5 „ „
Alcohol } Water }	a p a	100

It has one disadvantage—that it stains linen, but eusol will remove the stains

After a routine preparation the skin surface is cleared of all its transient flora, but the residents persist in the

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speaking, the sensitivity, so far as surgical procedure is concerned, is as follows —

> Streptococci, and to a less extent staphylococci and *Bacterium coli*, are sensitive to sulphonamides
>
> Streptococci and staphylococci are both sensitive to penicillin

Other organisms of less immediate interest to the surgeon at the time of operation are sensitive in more or less degree And there are many variations Whole groups may be rendered immune by a previous course of treatment Sub-groups may react differently to the main group Mixed infections may give a mixed response We have now reached a stage when most hospitals harbour a high percentage of penicillin resistant staphylococci That this is so argues strongly against the unnecessary or prophylactic use of any antibiotic

All these possibilities can be explored in the laboratory , but if the delay in waiting for the result might be harmful to the patient a mixture of drugs to cover the widest possible bacteriostatic range can be given, and this is what is done by most surgeons when prescribing from the operating theatre

Local Action of Sulphonamides Penicillin and the sulphonamides exert their main action systemically, though their local effects are by no means negligible If a sulphonamide is introduced early into a contaminated wound the growth of organisms is inhibited and infection may be prevented Unfortunately an excess of organisms interferes with this action So does the presence of pus In the stage of repair, however, when organisms are diminishing in number and pus is beginning to give place to serous exudate, the power of the sulphonamide is regained The tendency nowadays is not to use sulphonamide by itself, but as a vehicle for penicillin The

Americans have given it up altogether for local application because they doubt whether it does any good and suspect that it delays wound healing It it is used certain points should be remembered —

(1) Ordinarily sulphonamide powder is not sterile but it can be obtained ready sterilised

(2) It dissolves quickly in blood and may be washed clean out of the wound if hæmostasis is not adequate

(3) It is absorbed readily too and not more than 15 gm may be used at a time

(4) It should be distributed with an insufflator otherwise it may cake and act as an inert foreign body During one phase of the Burma campaign it was almost the rule for the surgeon at the base hospital to find a sulphonamide stone in the depths of a wound A colleague tells me that on two occasions he has had occasion to open an abdomen in which he had previously used sulphonamide The adhesions he found made a very deep impression on him

(5) Sulphonamide should never be employed in the neighbourhood of nerve tissue whether central or peripheral

The Use of Penicillin Penicillin is made up in several ways —

In powder 1 000 to 5 000 units per gramme of sulpha diazine May be insufflated every twenty four hours to produce a thick hoar frost over the area

In cream 250 units per gramme of 30 per cent lanette wax and water Twenty four hourly application to a burn will eliminate staphylococci and streptococci in a couple of days

In solution 200 to 2 000 units per cubic centimetre of sterile distilled water (not saline) Instillation can be made into a wound through fine tubes twenty four hourly Much stronger solutions are used for intramuscular injection

Of the local use of penicillin certain things can be said

(1) As with the sulphonamides, there is an increased risk of allergic reaction The skin is always ready to take up a challenge of this kind and show its resentment in a way that may be very distressing to the patient In recent years the general public have been dosed, or have dosed themselves, so liberally with these remedies that many people not normally allergic have become sensitised

(2) As an antiseptic penicillin suffers under similar handicaps to its forerunners Solutions are only likely to be retained in some sort of trough or depression Even so their concentration is soon changed by dilution and absorption Where retention for any length of time seems improbable owing to the anatomy of the part, the powder or a cream offer the best hope of securing a prolonged action

(3) Local administration which involves repeated taking down of dressings, or instillations through tubes, entails a constantly recurring danger of adding fresh infection to that already present Unless carried out with scrupulous attention to the details of asepsis, the last state of the patient may be worse than the first It was this kind of therapy that led to so much secondary infection of wounds during the first war The more inaccessible the depths of a wound the less likely is this method of treatment to succeed , failure to reach some remote corner with the solution may pave the way for deep-seated suppuration

(4) When the infection is spreading local treatment is bound to fail

(5) Local treatment is well suited to infections of joints, pleura, etc , because penicillin penetrates serous membranes tardily, either from within or without, which means that it is slow to find its way into the serous spaces when given systemically, but if deliberately introduced into

them remains where it is put to exert its action over a considerable period

From what has been said it is clear that the systemic route will be the one most commonly employed for the administration of penicillin The former objection that it involved repeated painful intramuscular injections is no longer valid since the newer solvents oil or procaine slow down absorption to a point when blood levels can be maintained by injections at much longer intervals—say 150 000 units twelve-hourly instead of 30 000 units four hourly

The Effect of Penicillin The Second World War gave surgeons and pathologists a unique opportunity of studying the action of penicillin on infected wounds In no other field apart from venerology has it been possible to make observations on such a big scale It was a common place to find hundred bedded wards filled with exactly similar cases which could be watched from beginning to end of treatment And yet no hard and fast rules can be deduced from the published results

Primary suture of the wound after a single insufflation or with provision for drainage was practised in some cases In others delayed primary suture was performed after a few days Or secondary suture was resorted to after a week or more Some of these wounds became infected especially when bone was extensively involved but most of them healed without setback In general streptococci disappeared promptly from any discharge there might be Other gram positive cocci might persist without doing much harm but usually gram negative pus was all that was left at the end of the treatment and this proved to be relatively innocuous Streptomycin is active against gram negative organisms so we shall be armed against the whole gamut in the next world war This antibiotic shows some of the instability of penicillin and like it is

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need not be excessive since it is a matter of prevention and not cure

By giving a patient sulphonamides which are not absorbed from the bowel for five or six days before operation it is now possible to reduce the contents of the colon to something approaching sterility The Augean stables are cleaned at last

Of the two preparations—sulphasuxidine and sulpha thalidine—the latter is the better It has less tendency to liquefy the stool and it can be given in smaller doses 0 15 gm per kilo of body weight to start with and the 1 gm four hourly night and day until the fæces are odourless But in all this there is no licence for operating on obstructed gut Sulphathalidine will not clear a cesspool nor will it alter the condition of distended bowel wall

Stone Solvents The search for something that will dissolve stone is almost as old as the search for a universal steriliser but it is much further from success A solution —solution G—is said to dissolve phosphatic accumulations in the pelvis of the kidney or in the bladder if it is brought into contact with them by some form of continuous irriga tion It is claimed that ether or alcohol introduced through a drainage tube will dissolve any stones which the surgeon may have overlooked during an operation on the common bile duct Before placing too much reliance on this manœuvre its value can be tested by dropping a few of the gall stones that *have* been removed into a test tube full of ether or alcohol and noting how much effect this strong concentration has had after the lapse of twenty four to forty-eight hours

better kept in the dry state For use it is dissolved in sterile distilled water, 1 gm to 4 ml, and given intramuscularly An average dose is 1 to 3 gm per diem

It is clear that mere numbers of bacteria do not overwhelm penicillin as they do sulphonamides Nor is pus a handicap to its activity, it may, in fact, be injected into an abscess cavity which has been emptied by aspiration, with some hope of curing the condition without resorting to open drainage Nevertheless the ordinary principles of surgery still hold good Penicillin or no penicillin, wound cleansing must be carried out Gross contamination, the presence of foreign bodies, or the retention of infected discharges, will render any antiseptic, old or new, ineffective And in the latter stages of the case sloughs, sequestra and fibrosis will delay healing no matter what effort is made to eliminate bacteria from the part

The newer antibiotics, at least for local use, are of less interest to the surgeon than penicillin and streptomycin, but if laboratory tests show that the organisms present are insensitive to these, then he need have no hesitation in resorting to chloromycetin, aureomycin, or other substance that the pathologist may suggest

Prophylactic Chemotherapy The peace-time surgeon, in the ordinary routine of work, is concerned about infection, but it is not the most pressing consideration in his mind Nevertheless there are times when he must be very glad of the protection given by chemotherapy and the antibiotics In an extensive or prolonged operation he can never be quite sure that his aseptic ritual will not have failed in some detail In other operations, *e g*, on the tracts of the body, when a fistula has to be dealt with, when inflammation is already present, the likelihood of trouble is still greater On all these occasions the drugs should be given early, so that the system is flooded with them *while the patient is still on the table* But the dosage

some qualification however By itself it is not 100 per cent effective though it can be made so quite easily Its boiling point can be slightly raised by raising the pressure in the steriliser a thing that happens automatically if the lid fits snugly At the slightly higher temperature five minutes boiling is enough to kill off all vegetative organisms Spores are protected by their capsules but these can be dissolved by the addition of 1 part in a 100 of sodium carbonate to the water The alkalinity is undesirable from some points of view but it is necessary for efficient sterilising by this method

Apart from any additions which may be made to it in the sterilising room there is no doubt that water coming from the town supply is often hard enough to leave a chalky deposit is sometimes otherwise chemically adulterated and may even become contaminated by bacteria if the plumbing arrangements go astray These are strong arguments in favour of a specially prepared supply for the steriliser

That all instruments must be completely immersed during the sterilising goes without saying but this is not enough every part of every instrument must be fully exposed. It follows that clamps artery forceps towel clips etc should always be opened before being put in the steriliser Corrosion is discouraged by alkalinity and still more by lack of oxygen

Free oxygen can be driven off the water by bringing it to the boil before the instrument tray is dropped into it If this is done as a routine it will not only keep the instruments in better condition but it will prevent any misunderstanding arising about the sterilising time which of course is always measured from when boiling commences There is also the advantage that any lime precipitated from the water is deposited in the steriliser and not on the instruments

CHAPTER XXIX

STERILISING AND DISINFECTING

"To reduce human errors to a *minimum it is* absolutely essential that both those who are in charge of sterilisation as well as those who actually carry it out should at first be amply qualified and should then be regarded as fixed staff"

Walter Dandy

DANDY'S requirements are not realised in this country, but no doubt some day they will be There can be little question that all sterilising in a hospital should be done in a central depot by trained technicians

Sterilising Instruments. Since time immemorial man has looked upon fire as the great purifier and heat is still the great steriliser

An hour in the hot oven at 160° C will sterilise anything Moist heat is more penetrating than dry, and organisms are more vulnerable to it, so that it only requires twenty minutes in an autoclave filled with steam under a pressure of 20 lb to produce the same effect Air must be driven off beforehand, either by the steam itself or by a vacuum pump, designed for the purpose It is essential that the steam should have free access everywhere, so all vents in drums must be opened and the contents be loosely packed This method is peculiarly suited to textiles, which are subsequently dried for twenty minutes under negative pressure Gloves may be similarly treated, after washing and drying, but they will not stand up to high temperatures five pound pressure for half an hour is sufficient Autoclaving is being increasingly used for instruments also, but the ordinary water steriliser is more convenient and therefore more popular at the moment

The sterilising powers of boiling water are subject to

that antiseptics disinfect but cannot be relied on to sterilise If it were not that the word disinfectant is associated with lavatory pans it would be better to adopt it altogether and reserve antiseptic for solutions used on the tissues.

(3) They are irritant to tissues This means that an instrument is not ready for use immediately it comes out of the antiseptic but must go through a water bath first. It may pick up fresh organisms in the process

(4) But the worst thing about antiseptics is that people believe in them and make them an excuse for all sorts of slovenliness and carelessness

Some Antiseptics

Cresols *Phenol or carbolic acid* is the father of all antiseptics and lysol is a descendant Because of their destructive action on the tissues they are used only for sterilising instruments *Lysol* is not water soluble and must be cleared in spirit which in its turn can be eliminated by water *Dettol* is a relative of phenol and lysol but is much less irritant and even in the pure state does not harm the skin

Mercurials *Perchloride of mercury* is another old stager Lister added it to phenol to form his strong mixture Like *biniodide of mercury* it readily combines with the protein of the tissues which quickly neutralises its action Perchloride (corrosive sublimate) forms a deposit on instruments and should not be used for sterilising them Biniodide has not this drawback but its action is very slow no matter how strong the solution It is commonly employed in a strength of 1 500 to dip the hands in after washing up probably with no effect at all *Oxycyanide of mercury* 1 3 000 is used for sterilising cystoscopes and 1 6 000 for irrigating the bladder

Alcohol See preparing the skin and sterilising syringes.

Antiseptics Heat really does sterilise, and it is a pity that it cannot be used for all surgical equipment, but unfortunately its action on metal-glass syringes is harmful, sharp instruments are blunted by it, and it melts gum-elastic catheters or bougies For these antiseptics must

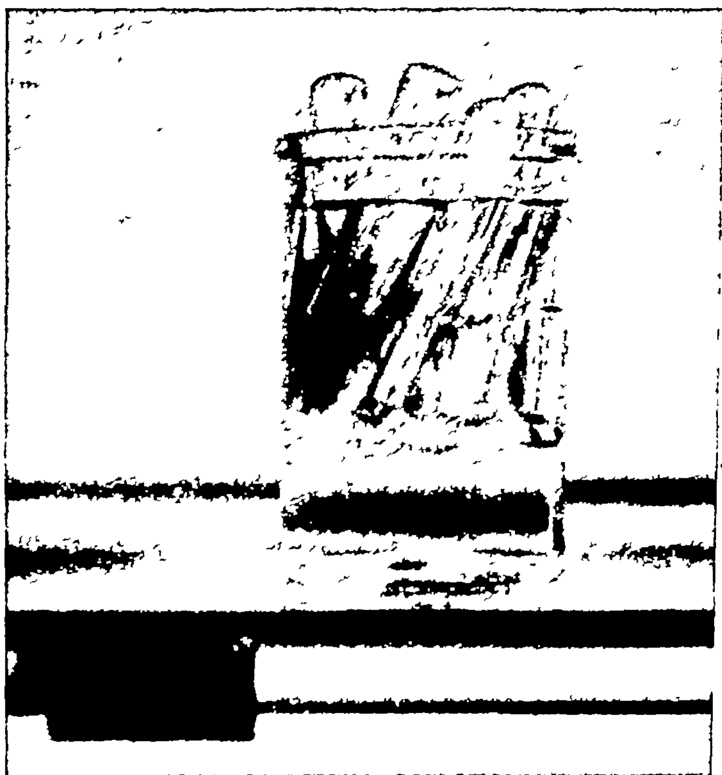


Fig 196 Half submerged ampoules are only half sterilised

be used, in spite of the disrepute into which they have fallen in recent years Before mentioning a few of the more important ones, some of their drawbacks are listed here —

(1) They are slow in action, and take hours or days rather than minutes to do their work

(2) They are uncertain It is not going too far to say

may even harbour them Professor Bulloch of the London Hospital demonstrated this conclusively by growing cultures from museum specimens that had been preserved in alcohol for thirty years or more This alcohol was full strength of course and its hardening properties interfered with its penetration Even in the proper dilution of 70 per cent the antiseptic action is by no means certain

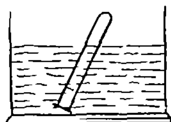


FIG. 197 Trapped air in syringes cystoscopes or receptacles, interferes with sterilising either by heat or antiseptics.

Ordinary hospital spirit may contaminate instead of sterilising the articles stored in it or passed through it Even when there is no direct contamination the spirit may evaporate or partly evaporate and leave the contents of the dish at the mercy of the elements It is not unusual to see dishes on the shelves of a casualty department in which the syringes are not more than half covered by the spirit and there is no protection from dust at all. No sterile receptable should ever be left lidless

All this notwithstanding there are times when other methods of sterilisation are not available and spirit must be used If the spirit is freshly decanted so that its strength is not altered by evaporation and the object to be sterilised is free from irregularities and recesses (*e g* an all glass syringe and not a glass-metal one) the risk is minimal so long as the following rules are observed The syringe or instrument should be —

(1) Dismembered
(2) Completely covered
(3) Left for at least twenty minutes
(4) Washed in water from an impeccable source

Sterilising Sharp Instruments Sharp instruments—needles, scalpels, scissors—must be sterilised in an antiseptic After thorough drying they may be stored in .—

Lysol } Spirit }	æquales partes.

or in —

Formaldehyde 37 per cent	86 ml
Water	72 ,,
Alcohol 95 per cent	842 ,,
Potassium nitrite	1 3 gm

The Bard Parker firm recommend this formula as suitable for the blades which they manufacture

Whatever the antiseptic it must be got rid of before the article come into use Water used for this purpose should come from a screw-capped, autoclaved bottle, which should not be employed a second time , saline from an ordinary stoppered bottle is rarely sterile

Sterilising Syringes Syringes are best sterilised in the autoclave or hot oven It is true that this melts the cement of the glass metal variety after a time, but in the long run replacements cost the community less than mishaps Most hospitals are now installing a central syringe sterilising service using these methods

The next best method to autoclaving is boiling This is open to the objection that when the water is not alkalinised sterilisation is incomplete, and when it is traces of alkali clinging to the barrel may cause trouble if the syringe is used for injecting drugs like penicillin, anethaine, nupercaine, etc Syringes intended for injecting, therefore, should always be subjected to the more rigorous process , those for aspirating to the less *It is asking for trouble not to keep the two sets entirely apart*

The practice of sterilising or trying to sterilise syringes in alcohol is a bad one Alcohol does not kill spores and

penetrate An hour should be allowed for sterilising and rinsing afterwards should be very thorough the urethra is particularly resentful of carbolic

An alternative method is to use a formalin jar for storing cystoscopes Here again the formalin is irritating even to the extent of causing dermatitis in nurses working with it

The insulating arrangements of the ordinary cystoscope will not withstand heat but this weakness has been overcome in some modern instruments and they can be sterilised by boiling It is important of course that the theatre staff should not confuse the two types of instrument

Coagulation Risks. Nothing favours the survival of bacteria more than the presence of organic matter If serum blood or pus is allowed to dry in the joint of an artery forceps or the barrel of a syringe it will be fixed by the next sterilisation and the organisms contained in it will be covered by a protective coating instead of being destroyed. This will happen whether sterilisation is effected by chemicals or heat

Even lukewarm water may coagulate protein All instruments therefore should be washed in *cold* water immediately after use This applies also to rubber gloves which can be conveniently sluiced under a running tap before they are taken off

Preserving Specimens A theatre nurse usually plunges any material intended for the laboratory into 10 per cent formalin in saline immediately it falls into her hands. This is good enough treatment for a fragment of tissue which is to go under the microscope as soon as it is hardened but it will shrivel up a larger specimen into a scarcely recognisable piece of pickled meat so that the pathologist will have the greatest difficulty in examining it with the naked eye And naked-eye examination is very

Sterilising Catheters Rubber catheters, like other articles made of rubber, can be boiled Some gum-elastic catheters can be boiled for a short while too, but this method of sterilisation softens them, and time must be allowed for the shellac to set before they are used Soaking in 1/1,000 oxycyanide is a more practical alternative

In many hospitals a formalin cabinet is preferred If formalin tablets are relied on to fill this with vapour the process is very slow—a matter of days At St Peter's hospital a container for liquid formalin is placed in the bottom of the cabinet and heated by a flame underneath Vaporisation is then quite rapid and the catheters are sterilised at the end of a couple of hours, but they must be bone dry to start with, otherwise the formalin will destroy the shellac in them

Ureteric catheters may be sterilised in a similar way It goes without saying that removal of the stilettes is an essential preliminary Without this the vapour will never get into the lumen

Catheters, whether urethral or ureteric, which have been used on a heavily infected case should be thrown away

Sterilising Endoscopic Instruments The weak point in an endoscope is the junction between glass and metal The two are united by a cement of no great strength Alcohol dissolves it So does carbolic in solutions stronger than 1/60 If a cystoscope is left in 1/20 carbolic for more than a few minutes the antiseptic will find its way into the lens system Thousands of telescopes are put out of action in this way every year

Carbolic 1/60 or oxycyanide 1/3,000 are sufficiently strong, but the cystoscope must be taken to pieces before it is placed in the container It is a principle of sterilisation by antiseptics that the solution must have complete freedom of access to all parts of the instrument There must be no crevices or air pockets to which it cannot

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important Only by looking at a growth is it possible to see how far it has extended, what glands are involved, and which are the parts that ought to be sectioned

Dukes advises that no preservatives at all should be used in the theatre, nor should the specimen be cut open or otherwise mutilated A wrapping of damp lint surrounded by cotton wool and mackintosh will, he says, keep it in condition for as long as two or three days when necessary if it is placed in a cool place When it reaches the laboratory it is stretched out on a Meccano frame, and only then allowed to come into contact with the formalin The delay in opening the specimen has this objection from the surgeon's point of view—that he misses the opportunity of examining it at a time when the details of the operation are fresh in his mind This is a considerable disadvantage, and I think one which outweighs the advantages claimed, at least so far as the younger surgeon is concerned He is still acquiring a knowledge of the "pathology of the living", and if he does not make a constant practice of examining the viscus or tumour he has removed before the steps of the operation have slipped from his memory he will miss information that might be of the greatest value to him Why were the symptoms and signs as they were, and not as they should have been? Why did the X-ray mislead? Why was removal difficult at a certain stage? The answers to some or all of these important questions may be cleared up by a careful examination of the specimen while the questions are still pressing later on question and answer may be put aside until the problem presents itself once more in a more difficult form

CHAPTER XXX

INSTRUMENTS

It is a mistake for a surgeon not to take a proper interest in his equipment. Whenever possible he should choose his own instead of being content with the often rubbishy legacy left by his predecessors. If he is wise he will aim at simplicity and standardisation. Forceps for instance are made with round bows, oval bows, round shanks, flat shanks, a great variety of joints including take-off, jaws curved, jaws angled, etc., etc., but there is really no need for all this elaboration. Efficiency both in manufacture and in use would be increased by eliminating it.

There is in fact no reason why many instruments employed for quite different purposes should not be of almost the same pattern. If the needle holder is of the bow handled type the hand accustomed from constant use to the one readily adapts itself to the other. Two entirely different instruments are then controlled by the same movement. For the same reason instruments of different size should be of identical pattern. It is possible to obtain matched sets—big, medium and small artery forceps differing from each other only in length.

The left handed surgeon is at a disadvantage when using ordinary instruments. This arises from the fact that the finger and thumb as they separate and approximate have a natural tendency to pull and push. So the thumb of the right handed person readily releases the rack of the forceps and holds the blades of the scissors in apposition. With the left handed the tendency unless corrected is the reverse. A scissors which is a little loose at the joint

is particularly awkward for a left-handed person, or, for that matter, a right-handed person working with his left hand Since special sets are not available for the left-handed, it is all the more important that the instruments used should be in first-class order

The standards of instrument making are so high in this country that it is hardly necessary for a surgeon to worry about the actual construction of the ones he selects Such things as symmetry, occlusion, accurate meshing, absence of slackness in joints, and smooth working of racks, can be taken for granted But it is always as well to make sure that the feel of an instrument is right before purchasing it This will depend on its balance and suitability to the hand of the individual who is going to use it It will depend also, in the case of a forceps, on the spring of the shanks A rigid shank means a great deal more strain on the joint and rack, this latter being the most vulnerable part and almost always the first to wear out

Needless to say, instruments should last long enough to justify the care and expense in their acquisition Most of them will be made of stainless steel, which contains chromium, and, for that reason, resists the action of antiseptics in the strengths commonly employed and is less likely to rust than ordinary steel This means considerable time saved in cleaning and does away with the need for re-plating But stainless steel cannot be tempered like carbon steel, and therefore is not so suitable for sharp instruments Scissors made of it prove satisfactory and so do chisels and gouges, but scalpels are better in the older material

Cleaning and Sterilising. Stainless or not, instruments should be thoroughly scrubbed in soap and water as soon after use as possible, with particular attention to joints, racks, and serrations If there is delay, even stainless steel (the adjective must not be taken in an absolute

sense) may become tarnished Sterilisation follows and then a very thorough drying This is a most important step Since moisture is the principal cause of corrosion it is essential that every particle of it should be removed before the instruments are put away Wiping them with a cloth will not do this effectively They should be laid out on a hot plate or on top of the radiator for ten or fifteen minutes with all joints wide open And the cabinet in which they are then stored should be situated in a place where the steam of the sterliser has no chance of reaching it The need for drying is no less when instruments are kept in antiseptic solutions if it is neglected the water carried into the solution may easily cause rusting

At least once a week all instruments should be oiled and polished Stainlessness depends on the polish so it is necessary to preserve it at all costs For this reason wire wool should not be used at any stage of the cleansing process or any other material that might cause surface abrasion

Hard water if used for cleaning or sterilising is apt to leave a deposit on instruments This can be loosened by leaving them in a 5 per cent solution of acetic acid over night after which it can be brushed off quite easily A joint jammed by such a deposit can be cleared with a mixture of alcohol and spirits of ammonia equal parts

Everyday Instruments *Artery Forceps* These have been modified in many different ways since Spencer Wells introduced them mostly with the aim of increasing their delicacy of action Halsted chose mosquito forceps which grasp a minimum of tissue because he believed that infection never lodges in a wound where there is no devitalised substance Other surgeons with the same object in mind have designed artery forceps with the serrations limited to the distal part of the jaws Dunhill

suggested forceps with jaws gently curved on the flat for ease of application

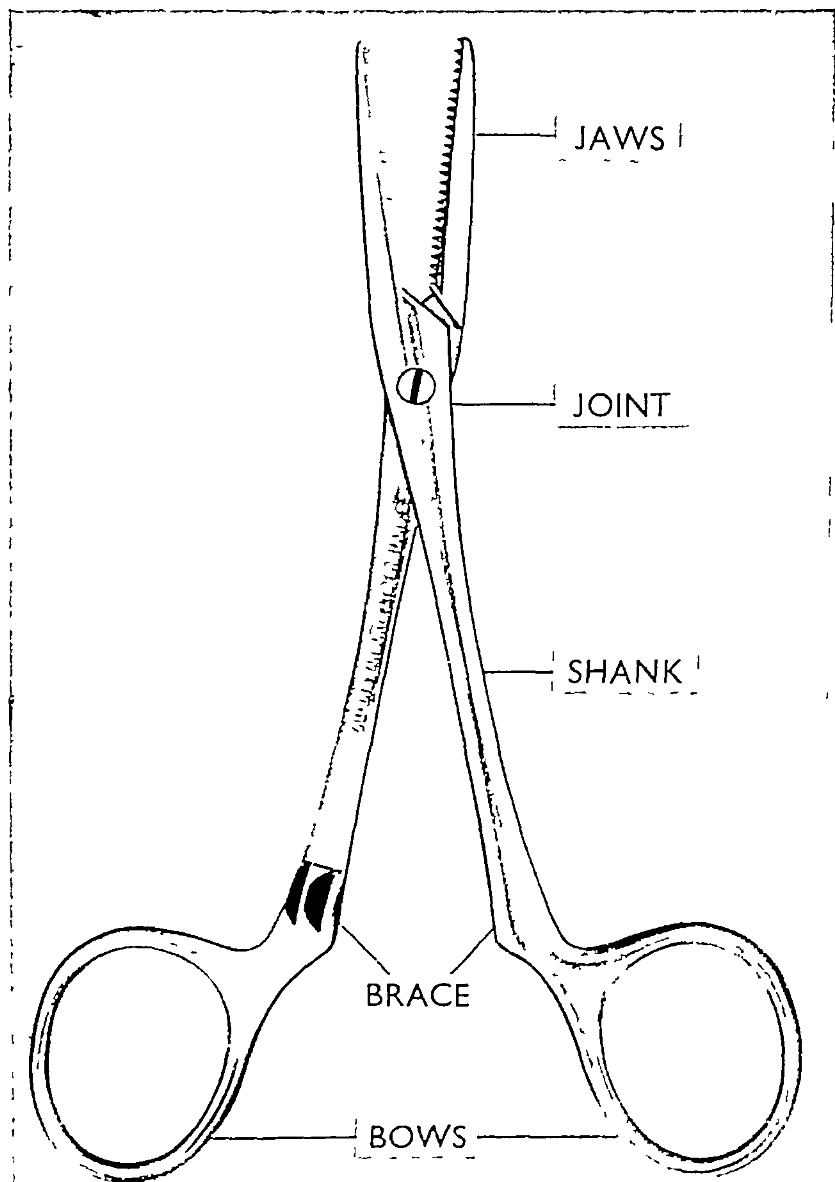


FIG 198 Parts of an artery forceps (*By courtesy of Messrs Allen and Hanburys*)

Whatever the type favoured the forceps should have box joints These are much more lasting than the old fashioned screw and much less likely to develop play as they grow old

Clamps Broadly speaking clamps are of two kinds—crushing and non-crushing Tissue grasped by a crushing clamp cannot be expected to survive and therefore must either be cut away or included in the suturing so that it will slough into the lumen of the bowel without interfering with the security of the union A non-crushing clamp has a much gentler grip with a certain amount of spring in the blades which do little harm to any tissue lying between them

A clamp may fail in its purpose because tissue slips sideways from its grip The longitudinal serration on the blades is designed to prevent this Cupping by leaving a thickness of uncrushed tissue between two crushed strips has a similar effect and is considerably less traumatic a fact that can be demonstrated quite easily by picking up a fold of skin on one s own arm with an instrument designed on these lines The slotting or fluting on the blades of the lighter type of clamp works on the same principle

Tissue can also escape from a clamp at its extremity This is because the blades are only parallel when there is nothing between them When tissue is included they work at an angle pressure is not evenly distributed and there is a persistent tendency for it to escape at the end In practice most clamps are made with slightly curved blades which occlude first at the tip and then gradually along their length This arrangement discourages but does not always prevent end slip Kocher countered the difficulty with his forceps by giving them tenaculum tips Some surgeons have avoided it altogether by designing handleless clamps the blades of which can be locked together simultaneously at either end

Retractors The automatic retractor spares the assistant at the expense of the patient In general, therefore, the ordinary type is preferable Certain points about it are worth making It should be bright enough to reflect light into the wound Its size and shape should be nicely adjusted to the need of the moment—depth, width, and curvature, must all conform to the parts being dealt with, if trauma is to be minimised Its flange should not be of a type that might do damage inside the abdomen—for instance, to the liver

Needles These must vary, but two or three sizes of each variety should suffice The straight are used for surface work and the curved for deep, and there must be a choice of round bodied and cutting, the latter for more resistant structures such as aponeurosis and skin Atraumatic needles, with the suture let into the shaft, so that a double thickness is not dragged through the tissues at every stitch, are becoming more and more popular for delicate surgery of all kinds These needles are easier to manage with the hand than in a needle holder

Some Bad Habits. The longevity and usefulness of an instrument depends on the treatment it gets, and this should be based on the cardinal rule —

> *Never put an instrument to a use for which it was not intended*

But even proper use may do harm An artery forceps (the most abused of all instruments) applied to a bulky pedicle is none the better for it The necessity may be unavoidable, but there is no excuse for employing it to hold plates or screws, pick up swabs, or anchor towels When an unyielding object is grasped between its jaws and the rack is closed, a considerable strain is thrown on the whole length of the instrument, not excluding the joint The steel may bend or break at the time , worse

still it may crack and only break later on when serving some more important purpose It is not unusual for instance to see an artery forceps applied to a length of tubing as a clamp The tubing is only compressible up to a point and the effect is as described If there is no alternative long forceps should be selected and applied only towards their point in this way the strain is distributed as far as possible along the jaws and shanks

One pair of scissors should not be asked to perform half a dozen different tasks The assistant should have a round ended pair for cutting sutures ligatures and stitches. This ensures that he is not using the Mayo s scissors when the surgeon wants them for dissection It also helps to keep the Mayo s scissors in good condition If they are employed for cutting nylon they will soon lose their edge which is ground to a sharper angle than usual and is more easily damaged on that account Dressing scissors are provided for cutting gauze etc If this is done with operating scissors and the gauze slips sideways between the blades their finely adjusted overlap may be lost for good

A scalpel blade whether of the interchangeable variety or not is made of hard steel and thus entails a certain brittleness. A very slight impact is enough to cause a deflection or fracture of the edge and therefore any contact between it and other instruments should be avoided

Dropping soiled or unwanted instruments on the floor or into a bucket with the specimen in order to get rid of them as quickly as possible may cause considerable damage

Antiseptics may stain and damage instruments The mercurials have a particularly bad reputation in this respect but are not much used nowadays It is not so commonly known that iodine can cause corrosion Some

times the needle which comes adrift from its butt and is lost in the tissues has been damaged in this way

A worn or damaged instrument should be sent for repair at once Delay may mean that it has to be discarded and exact replacement is not always possible If the instrument happens to be a favourite one the loss is all the greater

The Instrument Nurse However simple the armentarium, it is as well to keep most of it out of the way Nurse should be persuaded so to arrange the instruments that the ones constantly in use—scalpel, dissecting forceps, scissors, and a few artery forceps—are to hand, while the remainder are kept on her table, to be produced when asked for When a special instrument is required the surgeon should finish what has to be done with it before he lays it down Nurse can then reclaim it Her job is to see to the economical arrangement of essentials and so preserve that neatness and tidiness which should characterise the whole procedure Nothing advertises inefficiency in this respect so loudly as a jumble of instruments lying on the sheet beside the wound

Endoscopic Instruments These instruments are usually extremely delicate in construction, and it is not difficult to put them out of order The little lamps will not withstand more than a limited voltage, but if visibility is poor the surgeon seldom hesitates to ask for more In fact the obscurity may be due to some other cause than weak illumination—clouding of the medium, for instance This error can be avoided by adjusting the current before the instrument is introduced The precaution is worth taking, because, apart from the inconvenience, a fuse may fracture the glass of the lamp with unhappy consequences if there is any inflammable vapour in the neighbourhood The use of current from the town supply on these occasions is only permissible when the transformer is known to be

completely reliable. An ordinary dry battery is much less likely to cause any mischief Unfortunately it is apt to run down and cannot always be relied on to do its job

Leads are another source of trouble These are made of a number of fine wire strands which may snap one by one with clumsy usage (*e g* disconnecting by pulling on the lead instead of the terminal) The result is that the current passes through a narrower channel with the likelihood of generating more heat again destroying the insulation and possibly causing an accident.

The optical arrangements are often even more vulnerable than the lighting The telescope of an ordinary cystoscope for instance consists of an extremely thin tube with a prism at one end and a series of lenses disposed along its length which convey the image to the eye-piece at the other end. The tube is easily bent and the slightest jar may dislocate a lens In either case transmission of the light rays ceases and the part must go back to the maker before it can again be used.

The moral is that these instruments should be treated tenderly and inspected regularly by someone who understands a little about electricity

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